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HYBRID COMPUTER VEHICLE HANDLING PROGRAM

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Final Report

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16. Abstract

A hybrid computer simulation for vehicle handling studies has been implemented, checked out, and validated. The simulation has been programmed to study both solid rear axle and independent rear suspension vehicles.

Model validation was accomplished using parametric data representative of four 1971 vehicles: Volkswagen Super Beetle, Chevrolet Brookwood, Dodge Coronet and Pontiac Trans AM. Braking, steering, and combinations of braking and steering were the inputs to the simulated mathematical model for the validation tests.

This hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the standard passenger car vehicle handling test procedures and calculation of the associated comparison variables are simulation options. A special interactive user's interface has been added to allow program use by vehicle engineers as well as computer specialists.

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SECTION 1
INTRODUCTION AND SUMMARY

This document presents the latest version of the NHTSA Hybrid Computer Vehicle Handling Program (HVHP), which is operational at The Johns Hopkins University Applied Physics Laboratory. Many refinements have been incorporated into the simulation since the publication of Reference 2. In particular, the tire/road interface model (Reference 3) has been improved. Additional important features are:

1) Preprogrammed simulation initialization for performing any one of the six Vehicle Handling Test Procedures (VHTP).

2) Automatic data collection of system variables for immediate calculation of the Vehicle Comparison Variables (CV) associated with the selected VHTP (References 4 and 5).

3) The incorporation of a flexible set of input/output routines specifically designed as an engineer's interface for hybrid computer control and operation.

4) Reorganization of simulation model to minimize execution time.

The tire model improvements were made in conjunction with the Calspan Corp. under DOT contract HS-053-3-727. The VHTP initialization and comparison variable calculation were implemented in a general manner to allow redefinition of the

VHTP's and CV's for all classes of vehicles (passenger, recreational, commercial, etc.), instead of just automobiles. The extensive engineer interfacing features and input/output options were made practical by the expected continued use of the HVHP to perform vehicle handling research.

For program verification, a set of six VHTP maneuvers was run for four 1971 vehicles: VW Superbeetle, Chevrolet Brookwood, Dodge Coronet, and Pontiac Trans AM. The simulation comparison variable output was compared with that obtained from full-scale tests of these vehicles under contract DOT HS-031-1-159 (Reference 6). Good correlation between simulated and test comparison variables was achieved. The vehicle descriptors used in the simulation were not those obtained for the vehicles tested in the above contract but were instead obtained from like models of these vehicles used in conjunction with the Calspan Corp. contract. When published (Reference 3), these data can be compared with the latest Calspan full-scale tests. The simulation of the independent rear suspension VW or a solid rear axle vehicle, such as the Dodge, is performed with the same simulation.

User experience with the HVHP has shown that while performing parametric runs, 500 seconds of vehicle motion can be simulated in one hour of computer use. This translates to a cost of less than $0.50 per vehicle simulation second and represents a 50% utilization of the available computing time. Since this simulation, running at one-fourth of real time, is capable of 900 vehicle simulated seconds per hour, approximately 50% of the time is utilized for observing data and changing parameters. The $0.50 per simulated second should

be viewed as the current lower cost limit.

For program debugging and model checkout, fewer runs are made in a given time period than when parametric data is being produced. Therefore, the cost per vehicle simulated second would increase. However, general experience has indicated that on-line data observation for debugging decreases the total time required for program checkout. During the debug phase, HVHP cost usually ranges between one and two dollars per vehicle simulated second, with a decreasing trend to the $0.50 per second figure.

SECTION 2
FOUR-WHEELED VEHICLE HYBRID SIMULATION

2.1 INTRODUCTION

Contained in this section is a description of the four-wheeled vehicle hybrid computer simulation. The basic mathematical model is described in terms of seventeen degrees of freedom. The perturbing forces and moments which act on the vehicle are also considered. The simulation implementation and validation are discussed.

2.2 SIMULATION

2.2.1 Mathematical Model

The seventeen-degrees-of-freedom vehicle model consists of:

1) A basic ten-degree-of-freedom model of the vehicle body, front wheels, and rear axle.

2) A three-degree-of-freedom steering system model.

3) A four-degree-of-freedom wheel rotational dynamics model.

The basic ten-degree-of-freedom model regards the vehicle as an assembly of four rigid masses: the vehicle body, two front wheel masses, and the rear wheel axle combination (solid rear axle). The ten degrees of freedom consist of

the six standard translational and rotational degrees of freedom for the body, two for the vertical motion of each front wheel, and two for the rotation and vertical motion of the rear axle. When the vehicle model includes the independent rear suspension, each rear wheel is considered as an independent mass; and the vertical motion of each rear wheel is a degree of freedom.

The steering system model with three degrees of freedom represents the compliance in each of the front wheels and in the connecting rod. The tire moments about each king-pin axis are functions of the circumferential and side tire forces, tire aligning torque, the inclination and caster of the king pins, and the caster trail effects of the tires. Steering wheel displacement is the steering system input.

Four additional degrees of freedom (for a total of seventeen) are contained in the rotational equations of motion about the spin axis of each wheel. These equations, which include the differential effects of the rear wheels, yield the wheel rotation rates from which slip and, in turn, the circumferential and lateral friction coefficients are computed. The input to the equations can be either drive torque or brake torque.

The equations of motion of the vehicle body, wheels, and rear axle are perturbed by suspension, gravity, and tire forces and moments. The suspension equations include the effects of the springs, shock absorbers, and front and rear auxiliary roll stiffness. The suspension deflections are calculated relative to the suspension equilibrium position which varies with vehicle weight. Vehicle functions,

such as camber, caster, and toe angles, anti-pitch and anti-roll forces, and bump stop forces are input relative to the unloaded vehicle suspension positions. These functions are then corrected to the equilibrium position for varying vehicle weight when used for calculations within the vehicle model.

The tire forces (radial, circumferential, and lateral) are computed for each wheel. The radial load is proportional to the distance between the wheel center and the road. The circumferential force is the product of the tire radial load and circumferential coefficient of friction which is a function of wheel slip, radial load, and normalized slip angle. The lateral tire force is the product of the tire radial load, lateral friction coefficient, and two shaping functions representing the effects of normalized steer angle and longitudinal slip. Additionally, the lateral friction coefficient is a function of radial load and wheel velocity. Wheel aligning torques and overturning moments are included as functions of wheel radial load, side force, and camber angle.

2.2.2 Allocation of Analog and Digital Computer Tasks

The hybrid simulation block diagram of the automobile is shown in Figure A-1. Calculated in the digital portion are the sprung mass equations of motion, wheel orientation angles, and tire force equations. Wheel brake and drive torques, velocities of the tire contact point, and resultant forces and moments are also computed in the digital portion.

The analog computations include the suspension forces, shock absorber and wheel spring functions, longitudinal wheel slip, and circumferential coefficient of friction. In addition, the equations of motion of the unsprung masses and steering system equations are solved on the analog computer.

The hybrid simulation is time scaled to run at one-fourth real time, i.e., 20 seconds of clock-on-the-wall time is required for 5 seconds of vehicle simulation.

2.2.3 Implementation of the Mathematical Model

2.2.3.1 Analog Portion

The APL/JHU hybrid computer facility (Appendix C) contains analog machines manufactured by Electronic Associates, Inc. (EAI). The portion of model programmed on the analog computer is divided between models of EAI analog computers. The entire steering system is contained on an EAI 231-R and the rotational wheel dynamics, circumferential friction coefficient calculation, tire deflection, and suspension dynamics contained on an EAI 680. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 non-multiplying DAC's and 24 channels of analog-to-digital conversion (ADC's). The system contains a control interface which allows complete control of the 680 analog computer and data interface by the digital computer.

To expedite setup and checkout of the analog portion, a static analog test program for both the solid and independent rear is used. This was accomplished by programming the mathematical model equations solved on the analog as a digital simulation language program (Reference 7). The digital program output provided an independent check of the simulation. The static check results verify that the programmed analog portion of the simulation represents the respective vehicle mathematical model equations.

2.2.3.2 Digital Portion

The APL/JHU hybrid facility (Appendix C) utilizes an IBM 360, Model 91, for digital calculations. Model coding is performed in the Fortran IV language. Model calculations not assigned to the analog computers are performed digitally.

2.3 USER'S INTERFACE

The interface between the engineering user and the computer has been designed to maximize user control and information retrieval from the hybrid computer (Reference 14). The interface has been implemented by a set of generalized input/output subroutines. Using these communication routines, the following necessary tasks can be accomplished interactively at the CRT hybrid control console.

- Interrogation of any digital variable, including arrays, by name.

- Assignment of new values to any digital parameter or initial condition.

- Tracking and printing the values of any digital variable as a function of time.

- Printing the end of run values of any digital variable or parameter.

- Performing automatically a group of parametric runs varying one or more parameters or initial conditions by an arbitrary amount.

- Assigning new digital variables to the DAC's (digital-to-analog converters) and ADC's (analog-to-digital converters).

- Rescaling the digital variables output on the DAC's or input on the ADC's.

- Commenting the computer output with observations pertinent to the computer runs.

- Printing the value of all digital variables on command.

The usefulness of these routines is augmented by having the following features:

- The output unit for all digital computer responses is selectable (line printer, CRT, or both).

- Extensive subroutine error recovery which allows operation by untrained personnel.

- Free format input which obviates the need to always insert decimal points, spaces, etc. which would be required by Fortran syntax.

An explanation of the modules which are the building blocks of the routines, as well as a discussion of interaction, is presented in Appendix D.

2.4 VHTP MANEUVERS AND COMPARISON VARIABLES

2.4.1 VHTP Maneuvers

The simulation has the capability of self-initializing to perform any of the six automobile VHTP maneuvers and calculating the comparison variables appropriate for the selected VHTP. Utilizing the communication routines, a VHTP is selected by addressing the Fortran variable VHTPNO and assigning it a value from 1 to 6. The value of 0 is reserved for a special check run that verifies correct dynamic operation of the simulation. Once a VHTP has been selected, the system forcing function, pertinent to the VHTP, can be accessed. For all VHTP's the Fortran variable PFL represents brake line pressure. For VHTP's 2 to 6, the steering wheel input has the Fortran name STR2, STR3, etc. The names PFL, STR2, etc. can be used in the multi-run routine to simulate a series of VHTP tests in which the brake line pressure or steering wheel input is incremented. By convention, when a VHTP is selected in which the steering input is normally a parameter (VHTP 2, 4, 5), the STR variable contains the steering wheel rotation required to input 2.0 degrees of normalized steer. This value is required for run series in which the steering is incremented.

2.4.2 VHTP Comparison Variables

Comparison variables are output in both the single run and multiple run modes. If a single run is executed, a general comparison variable format is selected in which all CV's are output. However, only those pertinent to the selected VHTP will be non-zero. If a series of runs is executed, the

output is in a tabular format with the forcing function (steering wheel angle or brake line pressure) starting in the left column followed by the pertinent CV's. An example is presented in Figure 2-1, in which the following occurs:

1) VHTP 4 is selected.

2) The STR4 variable is interrogated to determine the steering wheel rotation for 2 degrees of normalized steer.

3) The steering wheel input is set equal to 300 degrees.

4) A single run is executed.

5) A run series of four runs is set up with STR4 initialized to two degrees normalize steer (NS) and incremented by two degrees NS in each run.

6) A multiple run is executed.

A representative parametric run series for each VHTP is presented in Figures 2-2a to 2-2f.

2.5 VALIDATION

2.5.1 Tire Effects Program

The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Calspan Corp. on DOT contract HS-053-3-727. For this contract,

```
**********    THIS IS THE FIRST OF TWO SPECIAL CARDS FOR THE 2741 ACM  *********
       VEHICLE HANDLING SIMULATION
ENGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
MAY        21  1974
TIME  14  0 11.76
OPTION
****  F
ENTER
****  VHTFNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.90
****  STR4 300.
****
OPTION
****  X
MAY        21  1974
TIME  14  2  7.18
RUN   1 HAS STARTED
OUTPUT BELOW
 AXAV=   0.0   DECL TIME=   0.000 AVCUR=   0.981 DIDMAX=   0.210 RTMAX=   0.126 DFLRT    0.126
AYMAX=   0.945 PHIMAX=   4.101 RMAX=   0.708 LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER= 300.000
LTRQMAX=   0.0   RTRQMAX=   0.0

OPTION
****  F
ENTER
****  VHTFND
   4.000
****
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  4 1
VAR
****  STR4
LOOP/VAL/INC
****  1 27.9 27.9
****
OPTION
****  XM
MAY        21  1974
TIME  14  4 16.24
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(  1) BETAMX(  1) RDIDMX(  1) CUVRAT(  1) AYMAX.(  1) RMAX..(  1)
  1     2      27.9      0.315E-02    0.200E-01    0.920E-01    0.134        0.694E-01
  2     3      55.8      0.105E 01    0.341E-01    0.260        0.342        0.106
  3     4      83.7      0.219E 01    0.646E-01    0.428        0.539        0.304
  4     5      111.6     0.375E 01    0.909E-01    0.573        0.691        0.409
OPTION
```

Fig. 2-1   HVHP USER'S INTERACTIVE CONTROL

```
TERMINAL ACTIVE
        VEHICLE HANDLING SIMULATION
LUGGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
JUNE       14  1974
TIME  16 14 46.99
OPTION
****  F
ENTER
****  VHTPNO 1
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS VARS
****  4 1
VAR
****  FFL
LOOP/VAL/INC
****  1 300 100
****
OPTION
****  XM
JUNE       14  1974
TIME  16 15: 1.46
RUN   1 HAS STARTED
OUTPUT BELOW
```

MULTI	TOTAL	FFL...(1)	AVAF.(1)	[illegible] (1)	AAP.(1)	SLIFI.(1)	SLIFI.(2)	SLIFI.(3)	SLIFI.(4)
1	1	[illegible]	0.419	2.73	[illegible] 01	[illegible] 01	[illegible] 01	[illegible] 1	[illegible] 01
2	2	[illegible]	0.561	2.04	[illegible]	[illegible]	.106	0.1[illegible]	0.1[illegible]
3	3	[illegible]	0.637	1.[illegible]	[illegible] 01	[illegible]	0.139	1.00	[illegible]
4	4	[illegible]	0.[illegible]	1.62	0.[illegible] 01	1.00	1.00	1.00	0.[illegible]

Fig. 2-2a HVHP INTERACTION FOR VHTP NO. 1

```
OPTION
****  IC
OPTION
****  F
ENTER
****  VHTPNO 2
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  4 1
VAR
****  FFL
LOOP/VAL/INC
****  1 [illegible] 100
****
OPTION
****  XM
JUNE       14  1974
TIME  16 16 [illegible]
RUN   5 HAS STARTED
OUTPUT BELOW
```

MULTI	TOTAL	FFL...(1)	AVAF.(1)	YMAX.(1)	PEAK.(1)	CUST.(1)	SLIPI.(1)	SLIPI.(2)	SLIPI.(3)	SLIPI.(4)
1	5	[illegible]	0.455	0.[illegible]	0.[illegible] 01	1.10	0.[illegible] 01	0.776E 01	0.[illegible]E 01	0.[illegible]E 01
2	6	[illegible]	0.539	0.297	0.[illegible]E 01	1.18	0.115	0.101	1.00	0.114
3	7	[illegible]	0.[illegible]	0.295	0.[illegible]E 01	[illegible]	1.00	0.125	1.00	0.[illegible]
4	8	[illegible]	0.[illegible]	0.297	0.[illegible] 01	0.312	1.00	0.156	1.00	0.997

Fig. 2-2b HVHP INTERACTION FOR VHTP NO. 2

```
OPTION
**** IC
OPTION
**** F
ENTER
**** VHTPNO 3
****
OPTION
**** IC
OPTION
**** MULTI
NUM OF LOOPS/VARS
**** 3 2
VAR
**** BMEN
LOOP/VAL/INC
**** 1 8 0
**** 2 10
**** 2 10 0
**** 3 13 0
****
VAR
**** BMPS
LOOP/VAL/INC
**** 1 57.6
**** 2 33.0
**** 3 37.7
****
OPTION
**** XM
JUNE      14  1974
TIME  15 23 12.14
RUN   9 WAS STARTED
OUTPUT OPTION
MULTI LOOP VAL BMEN..I  II BMPS..I  II [illegible]  II [illegible]  II [illegible]  II [illegible]  II
  1     9     8.00       57.6       0.511      0.315      0.9[illegible]      0.110
  2    10    10.0        [illegible].0       0.531      0.350      1.01       0.207
  3    11    13.0        37.7       0.415      0.331      0.973      0.177
```

Fig. 2-2c HVHP INTERACTION FOR VHTP NO. 3

```
TERMINAL ACTIVE
        VEHICLE HANDLING SIMULATION
CHANGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
JUNE      14  1974
TIME  15 58 [illegible].84
OPTION
**** F
ENTER
**** VHTPNO 1
****
OPTION
**** IC
OPTION
**** F
ENTER
**** VHTPNO 4
****
OPTION
**** IC
OPTION
**** FU
ENTER
**** F
ENTER
**** STR4
 [illegible].93
****
OPTION
**** MULTI
NUM OF LOOPS/VARS
**** 4 1
VAR
**** STR4
LOOP/VAL/INC
**** 1 55.65 55.[illegible]
****
OPTION
**** XM
JUNE      14  1974
TIME  16  1  [illegible].91
RUN   1 WAS STARTED
OUTPUT OPTION
MULTI LOOP VAL  [illegible]..I  II [illegible]  II BETDAV  II [illegible]  II [illegible]  II  [illegible]  II
  1     1     55.7     [illegible]   0.[illegible] 01   0.[illegible]     0.[illegible]2     0.1[illegible]
  2     2     112.     [illegible]   0.[illegible] 01   0.343     0.[illegible]2     0.255
  3     3     168.     [illegible]   0.1[illegible]      0.[illegible]     [illegible]     0.3[illegible]1
  4     1     [illegible]3.     [illegible].110      0.1[illegible]      [illegible]     [illegible]     0.[illegible]3
```

Fig. 2-2d HVHP INTERACTION FOR VHTP NO. 4

```
OPTION
****  F
ENTER
****  VHTPNO 5
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR5
  27.93
****
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  4 1
VAR
****  STR5
LOOP/VAL/INC
****  1 55.86 55.86
****
OPTION
****  XM
JUNE       14  1974
TIME  16: 7 46.00
RUN   5 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR5..(   1) AYMAX.(   1) DFL...(   1) BETAMX(   1) DELPSI(   1) UIN...(   1)
  1     5       55.9         0.177         9.90       0.137E-01    0.317E-02      45.0
  2     6      112.          0.372         6.48       0.399E 01   -0.[illegible]E 02    45.0
  3     7      168.          0.562         4.69       0.7[illegible]E-01   -0.117E 01      45.0
  4     8      223.          0.710         6.41       0.129       -0.[illegible]E 01    45.0
```

Fig. 2-2e HVHP INTERACTION FOR VHTP NO. 5

```
OPTION
****  F
ENTER
****  VHTPNO 6
****
OPTION
****  IC
OPTION
****  F
ENTER
****  IRLON
  0.5200
****
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  3 1
VAR
****  IRLOFF
LOOP/VAL/INC
****  1 0.9 0.05
****
OPTION
****  XM
JUNE       14  1974
TIME  16:11: 2.72
RUN   9 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PHIMAX(   1) PHIEMX(   1) RMAX..(   1) ZIMX..(   1) ZIMX..(   2) ZIMX..(   3) ZIMX..(   1) UIN...(   1) IRLOFF(   1)
  1     9      8.17       0.730       0.425      -0.892       0.615      0.624E-01   0.507E-01   50.0        0.900
  2    10      8.22       0.725       0.428      -1.01        0.636      0.330E 01   0.496E-01   50.0        0.950
  3    11      8.14       0.693       0.425      -0.915       0.658      0.831E 02   0.318E-01   50.0        1.00
```

Fig. 2-2f HVHP INTERACTION FOR VHTP NO. 6

"Research on the Influence of Tire Properties on Vehicle Handling," Calspan was responsible for refining the tire/road interface model which APL incorporated into the HVHP. Calspan monitored the simulation modification and examined the output for authenticity. Therefore, in addition to APL validation, the HVHP performance has been examined by engineers with extensive backgrounds in vehicle handling.

In the performance of DOT contract HS-053-3-727, over 2000 simulated VHTP's were run. Four vehicles were simulated: Chevrolet Brookwood station wagon, Dodge Coronet, Pontiac Trans Am, and Volkswagen Super Beetle. For each vehicle, a complete set of VHTP's was performed using simulated OE tires. Parametric studies were then run varying tire parameters to determine their affect on vehicle handling performance. The comparison variable graphs for the original equipment tire configuration runs are presented in Appendix F of this report.

2.5.2 Vehicle Handling Test Procedures

Time Histories for a typical set of VHTP maneuvers is presented in figures 2-3 to 2-8. The vehicle simulated for these runs is the 1971 Dodge Coronet.

2.5.2.1 Straight Line Braking

This run series determines the value of brake line pressure at which two wheels on the same axle lock-up. For this vehicle, both rear wheels were locked at 500 psi and and all four wheels were locked at 650 psi.

2.5.2.2 Braking In a Turn

This run series determines the value of brake line pressure at which two wheels on the same axle lock-up while the vehicle is executing a constant 0.3 gee turn. For this vehicle, the inside rear wheel was locked at 400 psi and both rear wheels and the inside front wheel were locked at 525 psi.

2.5.2.3 Turning On a Rough Road

For this run series, the vehicle traverses a bump grid while in a steady 0.4 gee turn. Three grid frequences are simulated: 9, 11, and 14 HZ.

2.5.2.4 Trapezoidal Steer

In this run series, trapezoidal steers of 4, 8, 12 and 16 degrees of normalized steer angle were used. For this vehicle, 28 degrees of steering wheel angle is required for 2 degrees of normalized steer. The CV output for the VHTP is presented in Appendix F.

2.5.2.5 Sinusoidal Steer

In this run series, sinusoidal steers with a maximum amplitude of 4, 8, 12 and 16 degrees of normalized steer angle were used. For this vehicle, 28 degrees of steering wheel angle is required for 2 degrees of normalized steer. The CV output for this VHTP is presented in Appendix F.

2.5.2.6 Drastic Steer and Brake

The purpose of these runs is to determine vehicle roll-over tendency. For this vehicle, a peak roll angle of 0.15 radians and a peak roll rate of 0.72 radians per second was achieved.

2.6 TIRE DATA

As previously stated, the current HVHP tire/road interface model was defined by Calspan as part of DOT contract HS-053-3-727. For this contract, Calspan tested many tires at their TIRF (Tire Research Facility) testing complex. As a convenience for working with APL and using the HVHP, the TIRF associated computer was programmed to process tire data into a format directly compatible with the HVHP tire model. Therefore, very little effort is required to prepare tire data for input to the HVHP for tires which have been tested on the TIRF machine. For tires tested on other tire test machines or flat bed testers, APL has the TIRF computer data processing program. When the tire test data has been properly formatted, the program output will be compatible with the HVHP. However, data preparation for the latter approach can be very time consuming.

2.7 HVHP INPUT DATA

2.7.1 Data Deck Description

A general input data deck is used with the HVHP. Defined in the data deck are the following:

1) Vehicle simulated.

2) Front and rear camber, caster, and toe functions via coefficients for a fifth order polynomial approximation.

3) Front and rear brake torques as pairs of brake pressure in, brake torque out data points.

4) Lateral friction coefficient degradation with circumferential slip as pairs of percent slip in, percent of lateral friction coefficient out data points.

5) Interactive OPTIONS.

6) Default output variable list for the Track Option.

7) Default output variable list for the Table Option for VHTP's performed in the multi-run mode.

8) Initial values of input members of the PARAM vehicle descriptor data array input as pairs of array element number and initial value.

9) Digital-to-analog converter variable and scale factor assignments input as pairs of digital variable and corresponding scale factor.

10) Analog-to-digital converter variable and scale

factor assignments input as pairs of digital variables and corresponding scale factor.

11) PARAM data array members which are used to redefine VHTP condition inputs as sequential numbers representing the PARAM array element number and the corresponding variable value for the initial check run and each VHTP 1 to 6.

The input data decks for the four passenger vehicles recently simulated are presented in Appendix E. Also presented in Appendix E is a sample of the PARAM Table for each vehicle which is output to the system line printer prior to each simulation run. This provides PARAM value documentation.

2.7.1.1 Vehicle Identification

The first data card is used to document the vehicle being simulated. Any message confined to 80 characters is allowed.

2.7.1.2 Camber, Caster, and Toe Functions

The next six data cards define the front wheel camber, caster, and toe and the rear wheel camber, caster, and toe functions for wheel displacement from the unloaded vehicle suspension equilibrium position. One function is defined per data card which contain the six coefficients required to specify a fifth order polynomial approximation to the appropriate function. The order of the data is C0, C1, ..., C5. C0 is the value of the function (camber, caster, toe) at the equilibrium

suspension position of the unloaded vehicle. The original data for these functions is presented in Appendix E.

2.7.1.3 Brake Torques

The next group of data cards defines the front and rear brake torque functions. The function is specified as pairs of data points per card, a value of brake line pressure and the corresponding value of the brake torque. A group of cards (2 to 20) defining each function is ended by a data card containing the number 99999. A linear interpolation routine is used to obtain torque values for brake line pressures between specified data values. Conventionally, the front and rear brake torque functions are identical and brake proportioning is accomplished using PARAM array elements 238-241.

2.7.1.4 Side Force Shaping Function

The next group of data cards defines the functional relationship between the side force and circumferential slip. Pairs of data points are input per card as percent of slip and the corresponding percent of possible side force which is attained. The function data (2 to 20 cards) is terminated by a card containing the number 99999. Linear interpolation is used between data points to obtain intermediate function values.

2.7.1.5 Interactive Options

The next group of data cards defines the names usable in response to the OPTION cue for simulation interactive control. The input of any of these names at the hybrid

control console in response to the OPTION cue will enable a specific interactive routine. The interactive routines are specified in Appendix D.

2.7.1.6 Track Output Variables

The next group of cards defines the initial set of interactive variables to be output if the track OPTION is enabled. Fifty variables may be selected on as many cards as is required. This group of cards is terminated by a blank card. This list may be altered interactively using the Track OPTION.

2.7.1.7 Table Output Variables

The next group of cards defines the variables to be output at the end of each run when the multiple run execution mode is enabled. This group contains seven cards, one card for each VHTP (the first six) and one for the check run. A maximum of nine variables can be specified per card. If the Table variables are respecified interactively via the Table OPTION for the execution of a VHTP, the variables in this data group will be restored when that VHTP is reselected.

2.7.1.8 Vehicle Descriptor and Tire Data

The next group of cards is used to input the initial values of variables which are elements of the PARAM data array. This array is used to input all vehicle descriptor and tire model data. Since the array is also used for purposes

other than data input, such as storing values for program calculated initial conditions, program flow switch values, etc., all PARAM elements need not be initialized. The definitions of all PARAM elements is presented in Section 4 of Appendix B. The subset of PARAM elements which represent vehicle descriptors or tire model coefficients is presented in Section 5 of Appendix B. Data is input one PARAM element per card by indicating the PARAM element address followed by the assigned value.

2.7.1.9 Digital-to-Analog Variables

This group of cards specifies which variables will be output from the digital to the analog computer and the scale factor that will be associated with the digital-to-analog conversion (DAC). Any variable name which has been specified as an interactive variable may be output. If the variable output is used in the closed loop vehicle model, the scale factor must be consistent with the use of the variable on the analog computer. If the variable output is used strictly for strip chart recorder display purposes, the scale factor can take on any rational value. The maximum expected value of the variable is an appropriate starting value. Either the variable, scale factor, or both may be reassigned via the interactive OPTION DACA. Forty-eight cards must be included, one for each digital-to-analog output in the order of assignment to the DAC's 0-47. Each card contains a variable name followed by its normalizing scale factor.

2.7.1.10 Analog-to-Digital Variables

This group of cards specifies which variables will

be input from the analog to the digital computer and the scale factor that will be associated with the analog-to-digital conversion (ADC). Any variable name which has been specified as an interactive variable and exists on the analog computer may be input. The scale factor must be consistent with the use of the variable on the analog computer. Either the variable, scale factor, or both may be reassigned via the interactive OPTION ADCA. A change in variable implies a wiring change on the analog patch panel. Twenty-eight cards must be included, one for each analog-to-digital input in the order of assignment to ADC's 0-27. Each card contains a variable name followed by its analog scale factor.

2.7.1.11 VHTP Initialization Data

The last group of cards allows the input of data that is used for initialization of the simulation for performing a specific VHTP maneuver. Since this data is input, VHTP conditions can easily be varied. Twenty-seven data cards are required with each card containing a PARAM element address and a value for the variable represented by that address for the check verification run and each VHTP 1 to 6, in that order. The PARAM element addresses shown in the data lists are required for VHTP initialization. However, the input order is not fixed.

2.7.2 Springs, Shock Absorbers and Load Dependent Data

In addition to the data deck, the spring and shock absorber functions are simulation inputs. The shock absorber functions are input using analog function generators.

The spring forces are generated using a combination of analog and digital techniques. In order to achieve correct placement of the compression and rebound bump stops, relative to the suspension equilibrium position, suspension deflection parameters must be specified for loaded vehicle conditions.

2.7.2.1 Spring Functions

The front and rear spring functions are input as three line segment approximations to the actual curve for restoring force versus suspension deflection from the equilibrium position. The three segments are a linear region for plus and minus deflections about the equilibrium position and a segment for each of the compression and rebound bump stops. The bump stop segments are specified by a multiplier factor which is the ratio of the curve slope at the bump stop segment relative to the linear segment. A different multiplier can be input to represent the rebound and compression bump stops individually.

The linear segment is generated on the analog computer. Bump stop impact is tested in the digital computer and an auxiliary force, representing the bump stop contribution in excess of the linear portion, is calculated and output digitally. Bump stop locations should be specified relative to the unloaded vehicle equilibrium suspension position.

2.7.2.2 Shock Absorber Functions

The front and rear shock absorber functions are

generated using analog function generators. Since the function generator is a versatile analog device, the shock absorber characteristic can be represented as a general function of suspension deflection rate. However, in practice, representation by three or four line segments has proven sufficient. The function may be specified for input purposes either graphically or as a list of slopes for various suspension deflection rates.

2.7.2.3 Load Dependent Data

Since the HVHP calculates suspension deflections relative to the suspension equilibrium position for all load configurations, information specifying the suspension travel from the unloaded vehicle suspension position must be provided. Of particular interest are the loaded vehicle configurations for driver control used in VHTP's 1-3 and for automatic controller used in VHTP's 4-6. The vehicle parameters which are load dependent and their corresponding PARAM element addresses are as follows:

Variable	PARAM Address
MS	1
ZF	4
ZR	5
a	6
b	7
IX	11
IY	12
IZ	13
DELF	92
DELR	93

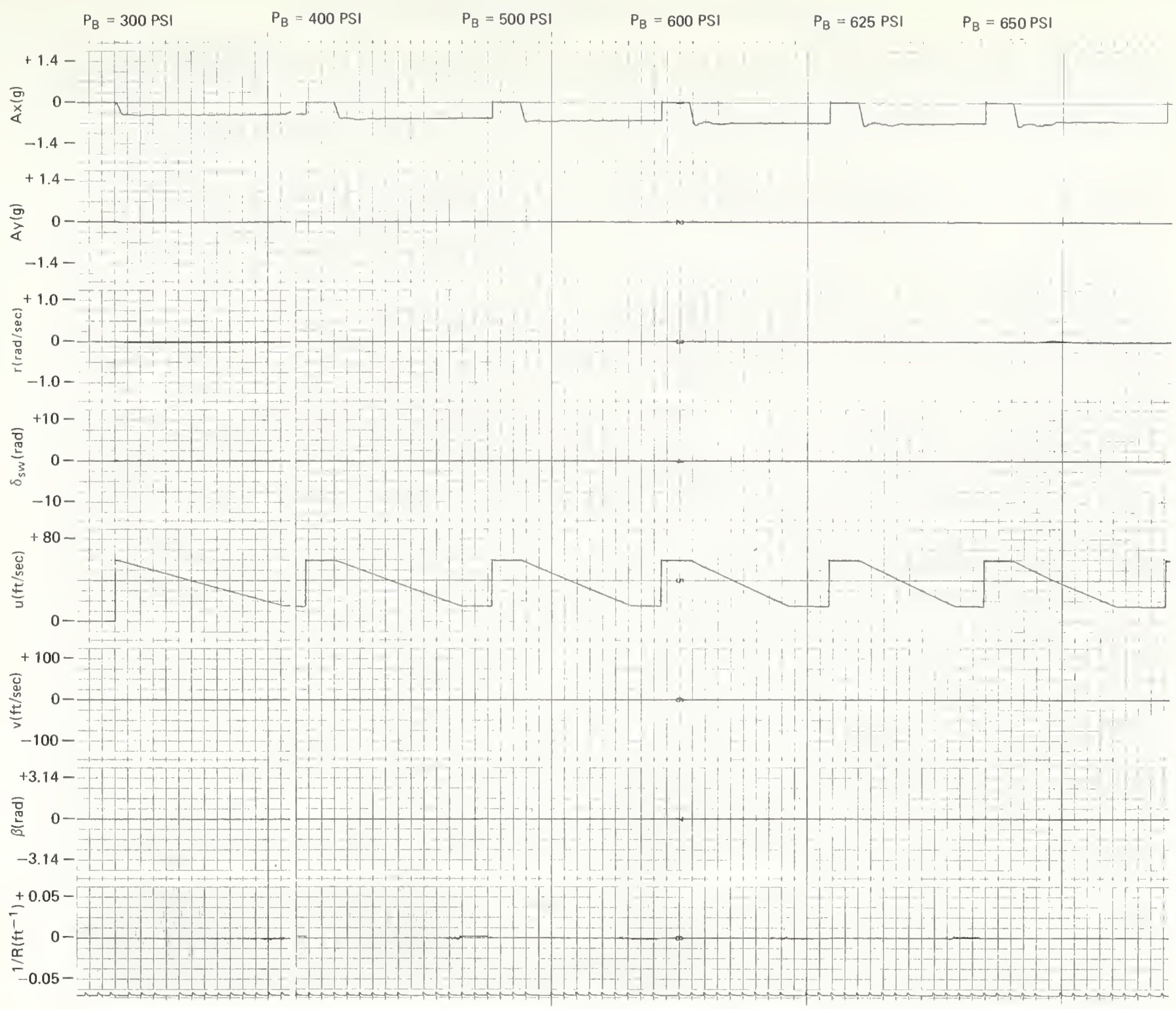

Fig. 2-3a TIME HISTORIES - STRAIGHT LINE BRAKING

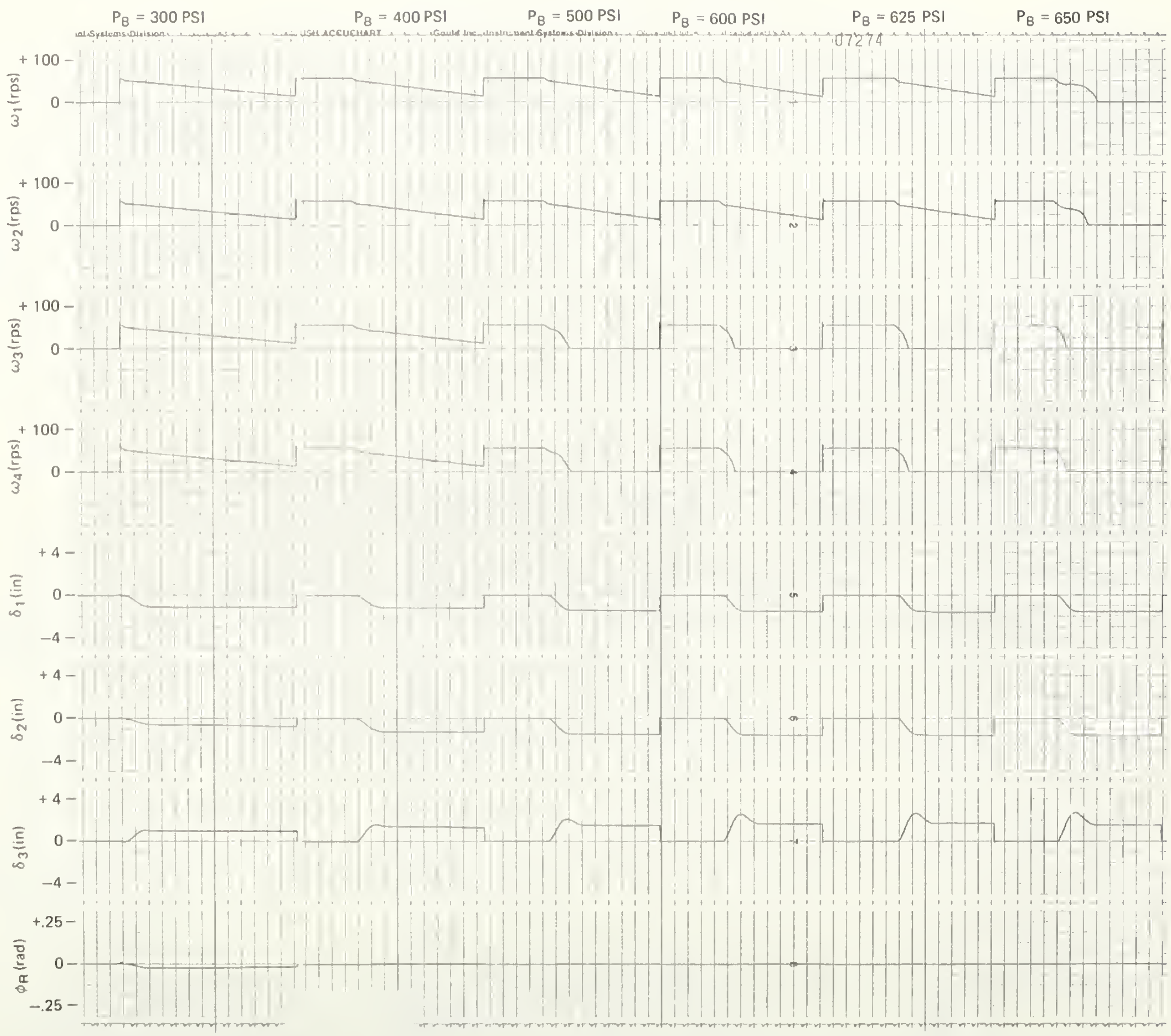

Fig. 2-3b TIME HISTORIES - STRAIGHT LINE BRAKING

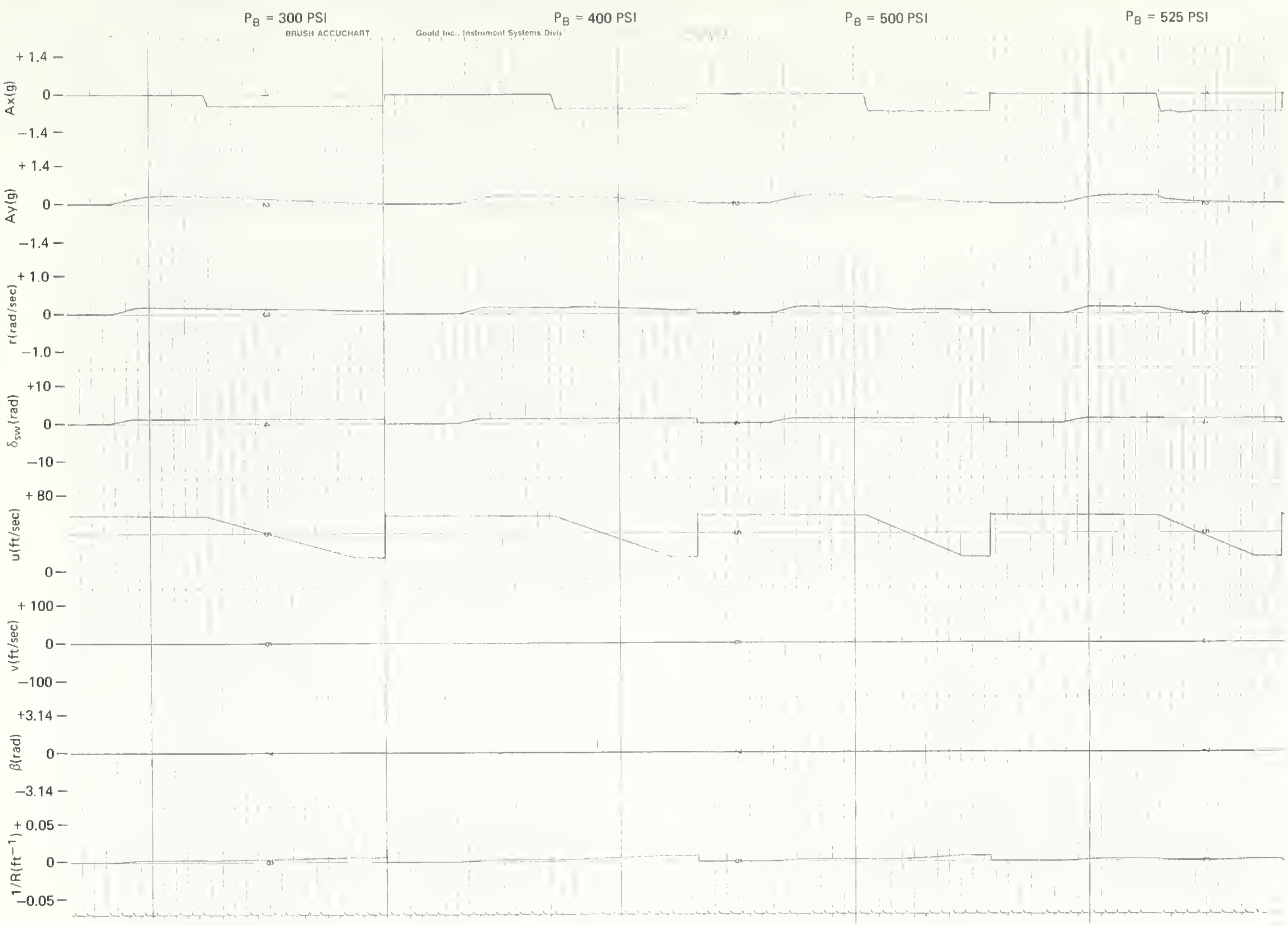

Fig. 2-4a TIME HISTORIES - BRAKING IN A TURN

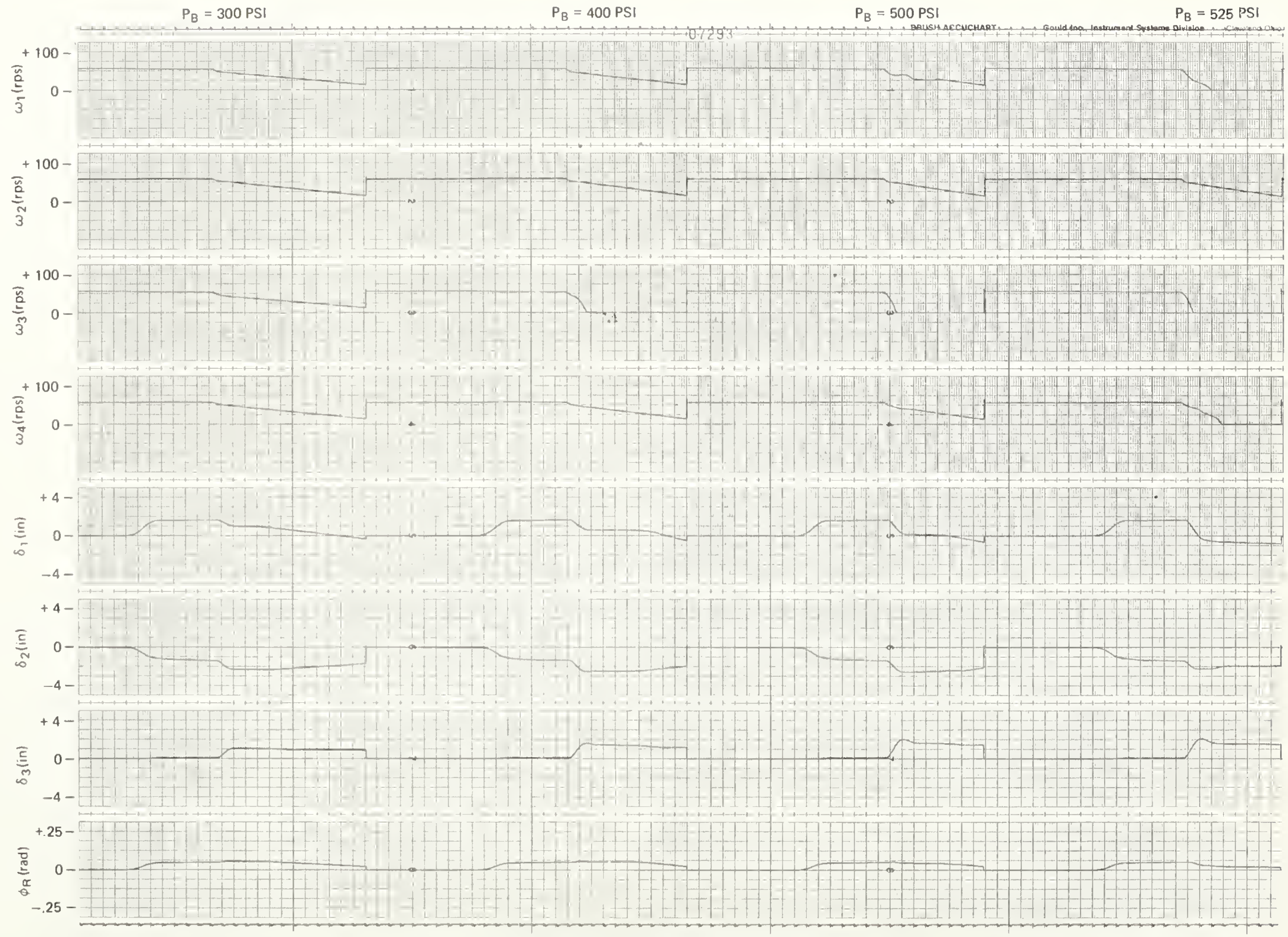

Fig. 2-4b TIME HISTORIES - BRAKING IN A TURN

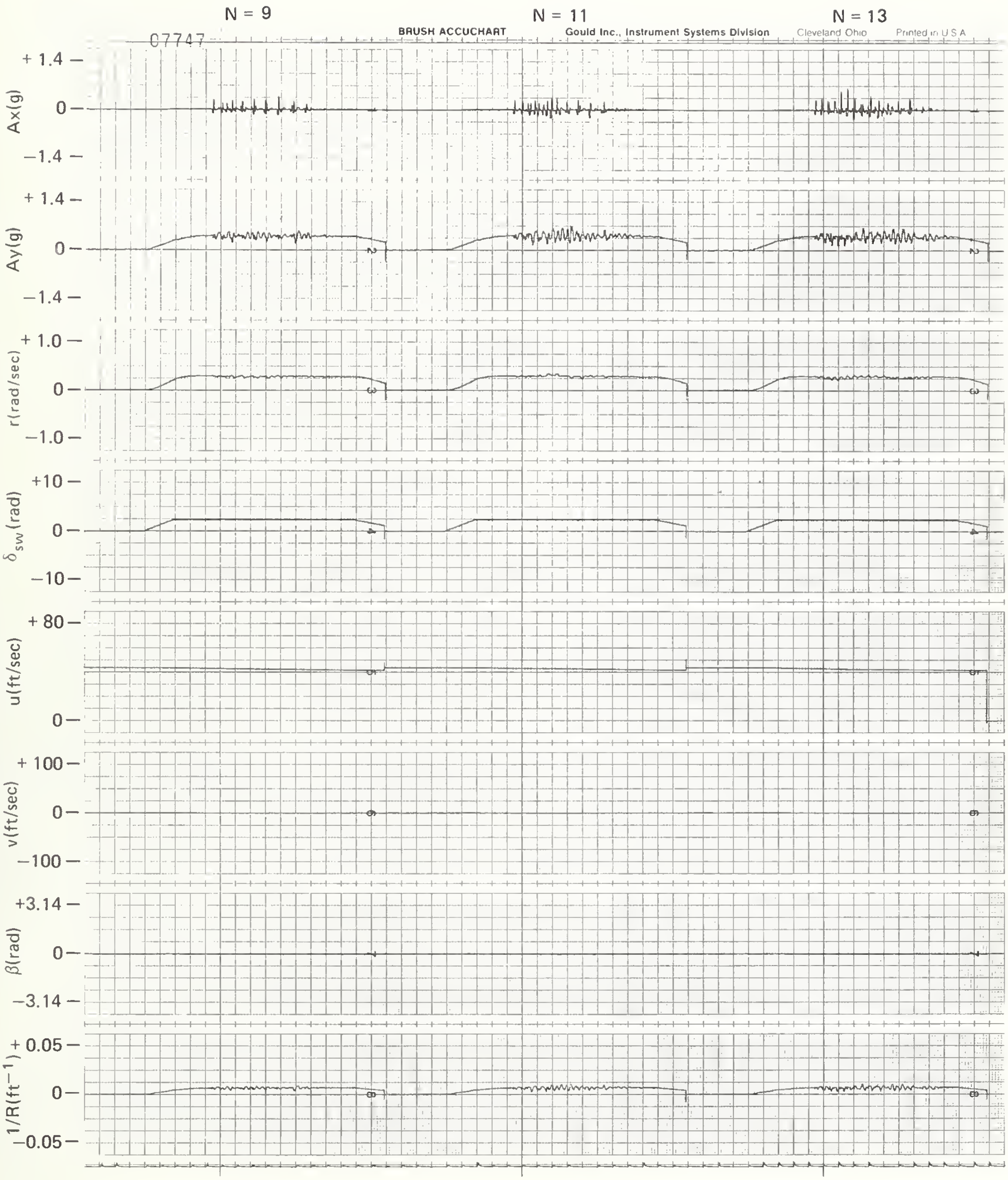

Fig. 2-5a TIME HISTORIES - TURNING ON A ROUGH ROAD

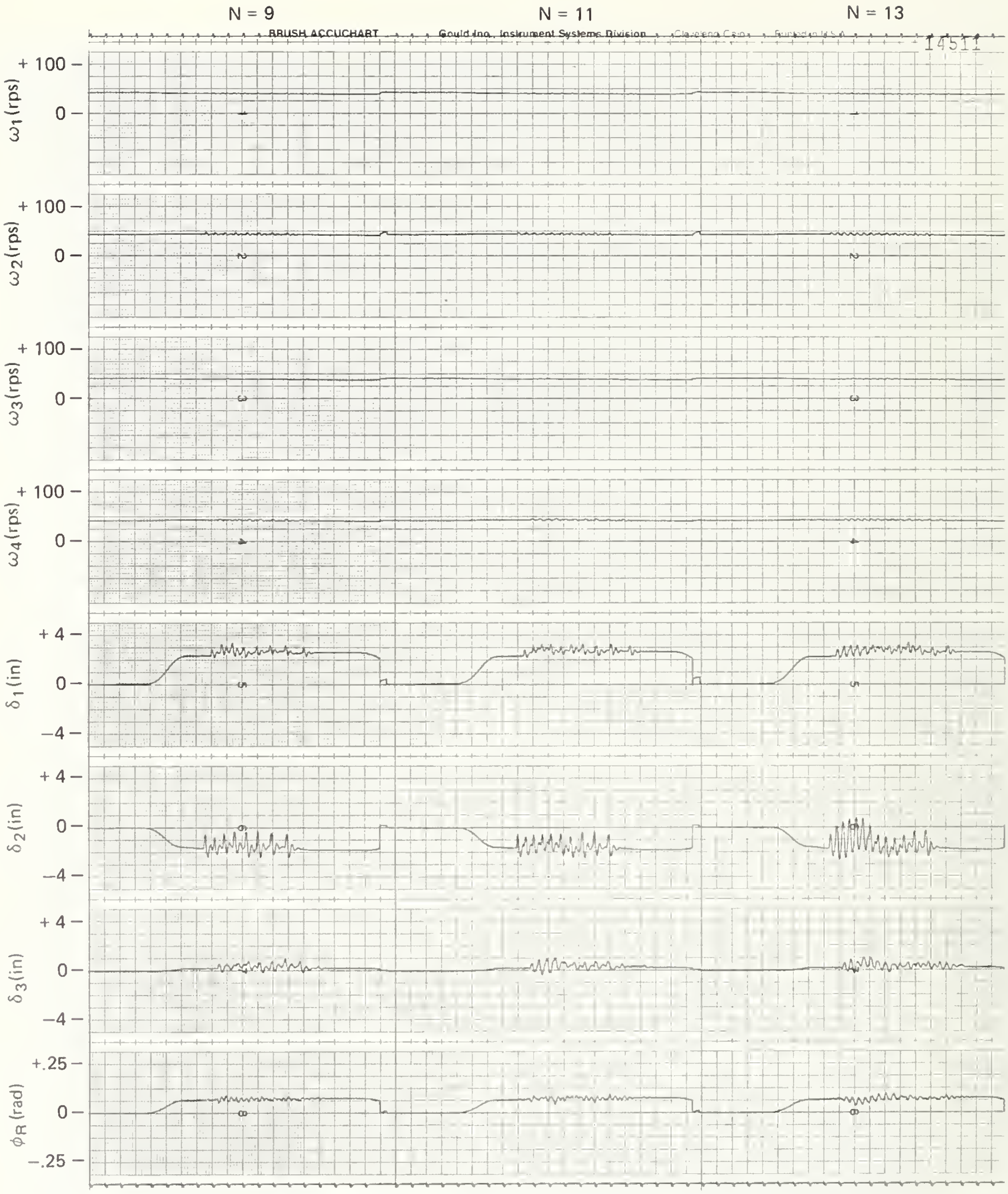

Fig. 2-5b TIME HISTORIES - TURNING ON A ROUGH ROAD

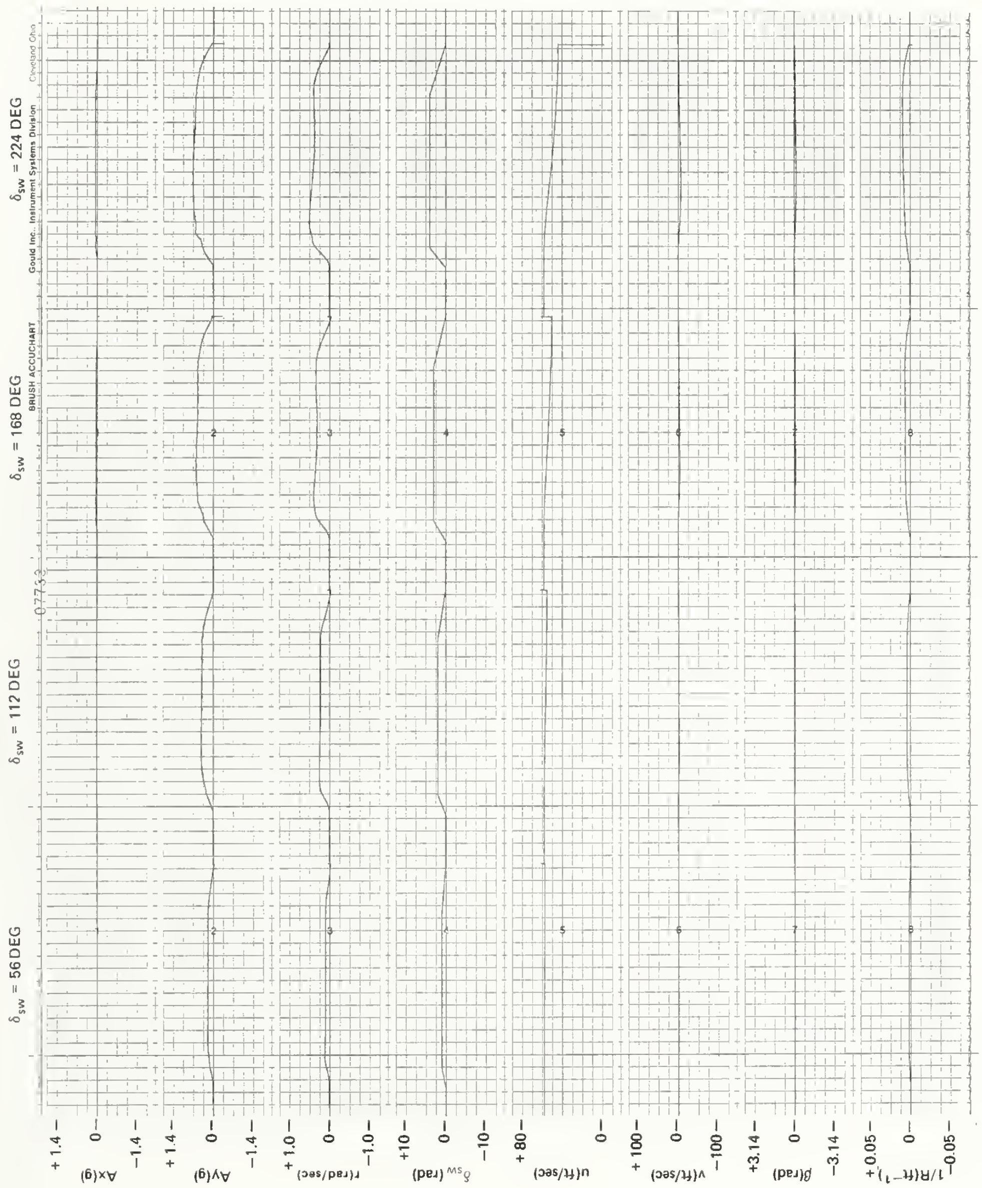

Fig. 2-6a TIME HISTORIES - TRAPEZOIDAL STEER

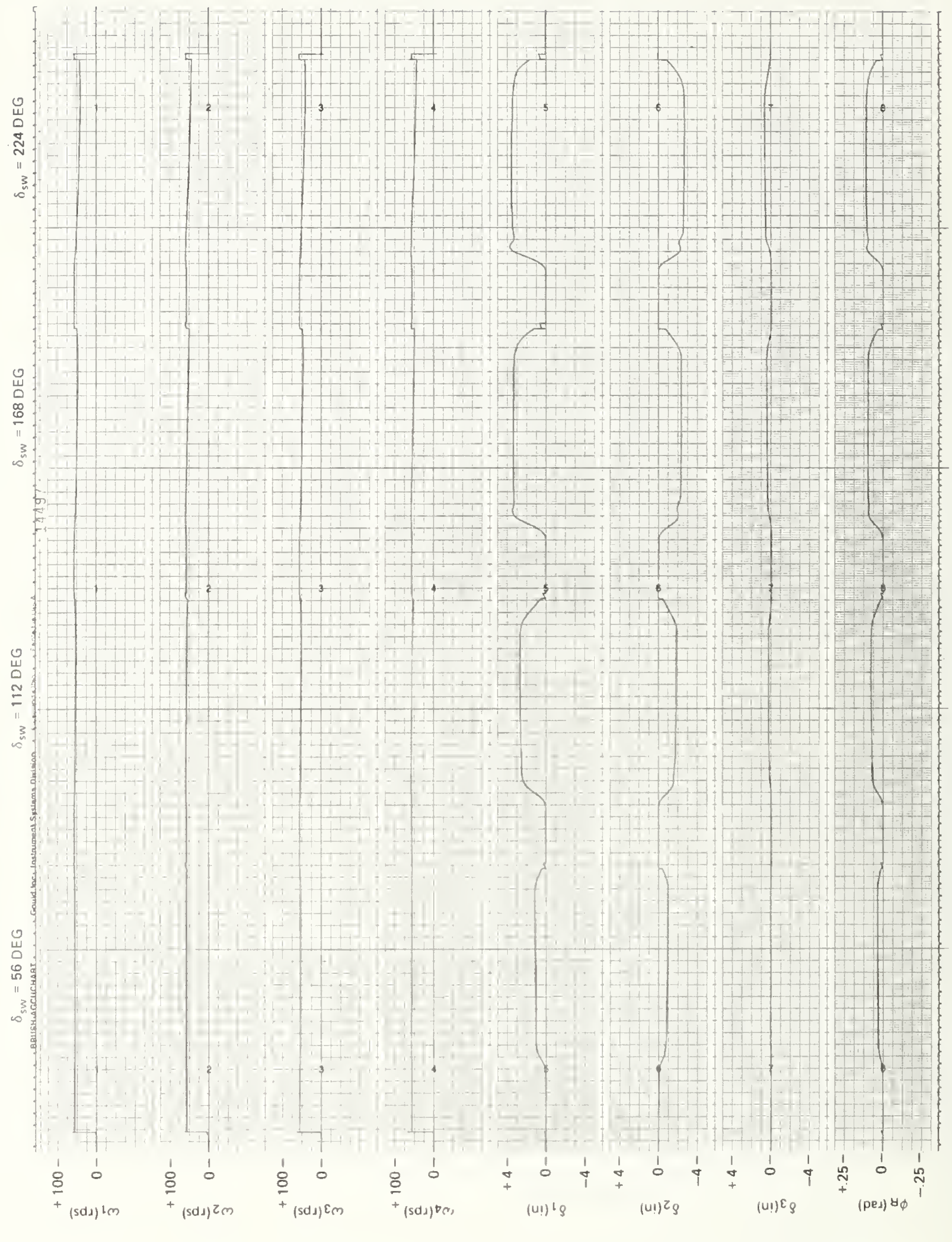

Fig. 2-6b TIME HISTORIES - TRAPEZOIDAL STEER

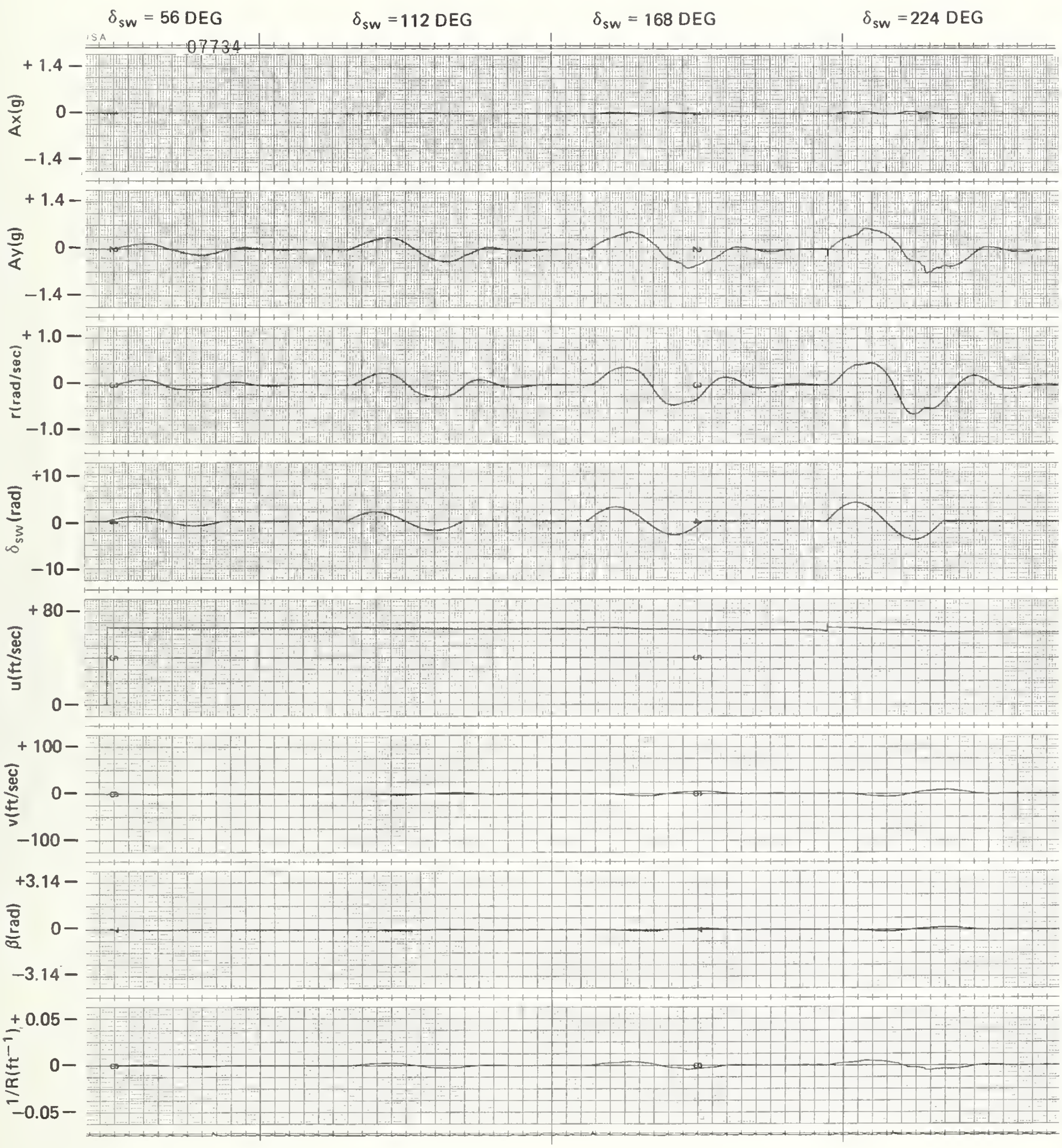

Fig. 2-7a TIME HISTORIES - SINUSOIDAL STEER

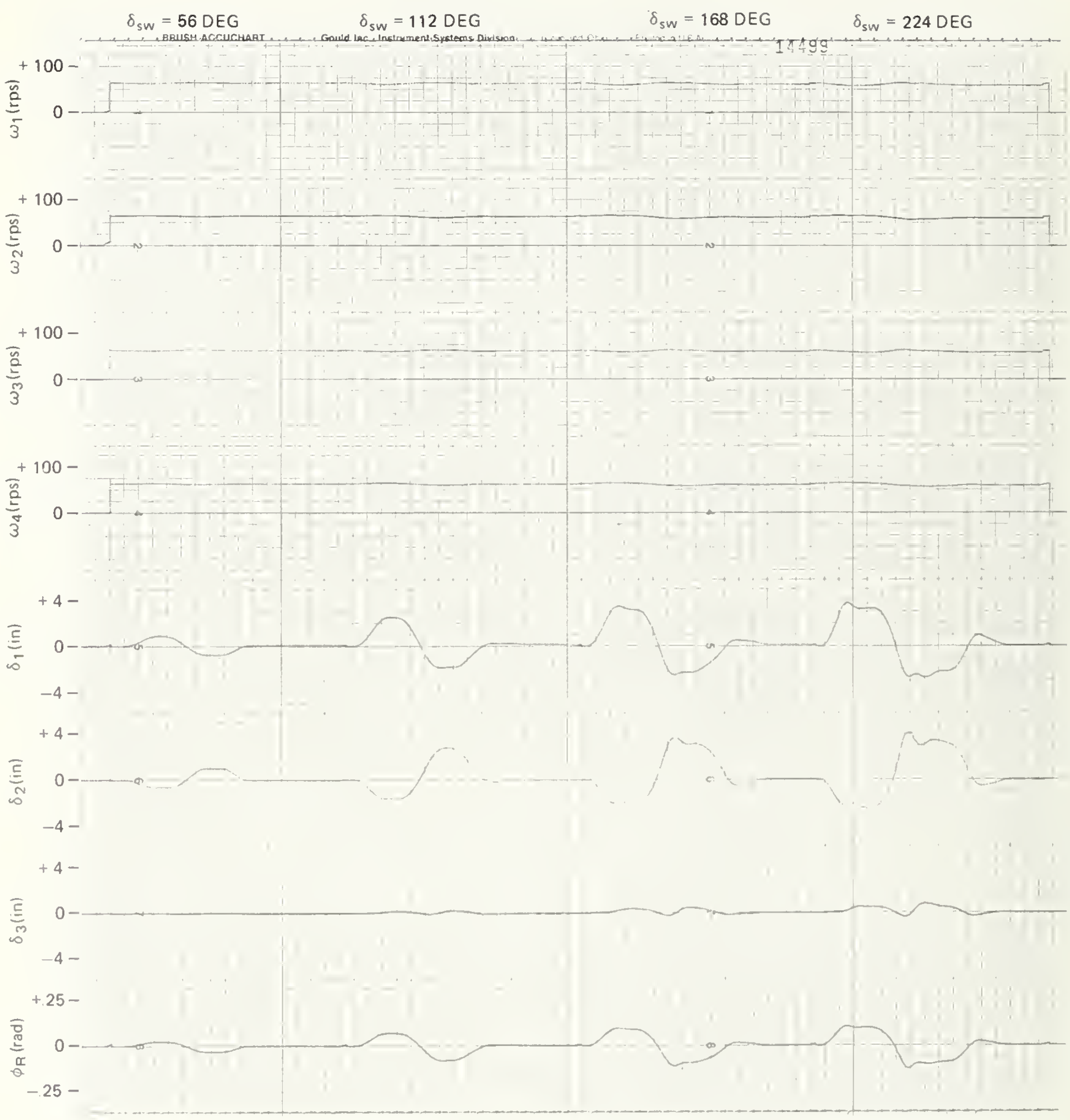

Fig. 2-7b TIME HISTORIES - SINUSOIDAL STEER

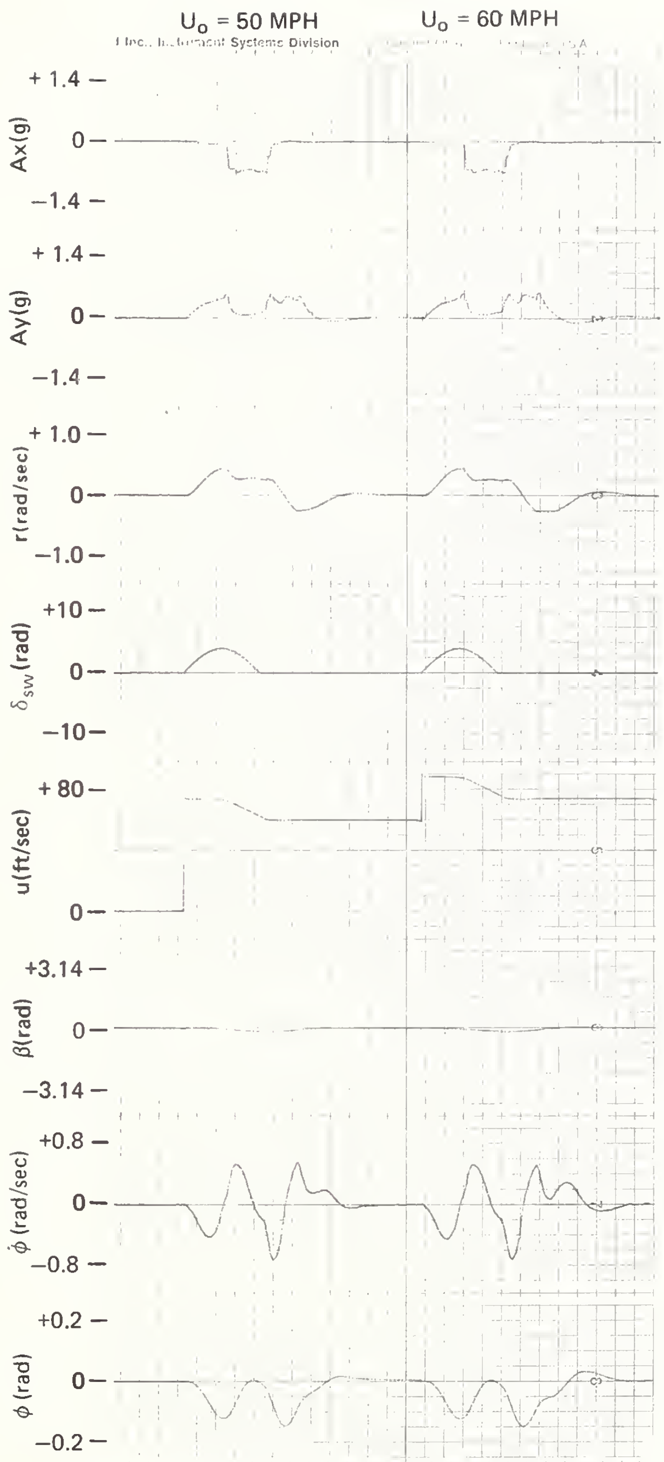

Fig. 2-8a TIME HISTORIES - DRASTIC STEER AND BRAKE

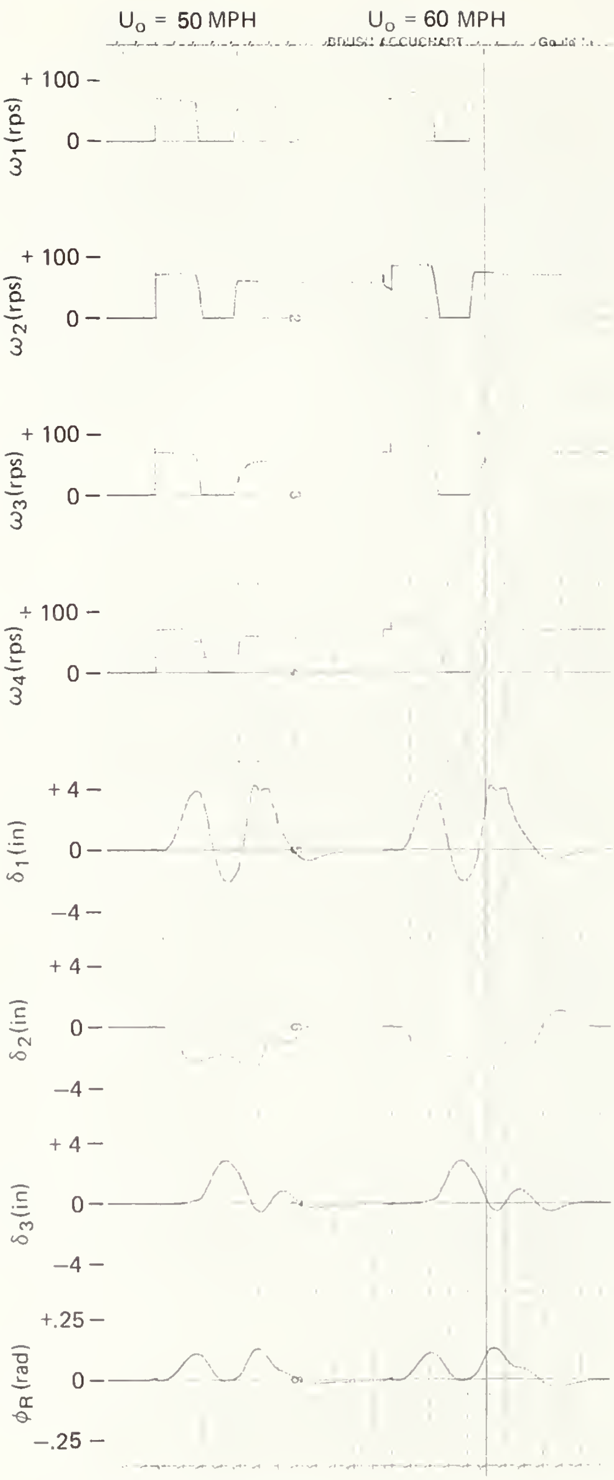

Fig. 2-8b TIME HISTORIES - DRASTIC STEER AND BRAKE

SECTION 3
CONCLUSIONS AND RECOMMENDATIONS

The Hybrid Computer Vehicle Handling Program (HVHP) has demonstrated realistic dynamic simulations of passenger vehicles with an independent front suspension and either an independent or solid axle rear suspension. The performance of simulation runs, especially those involving the six vehicle handling test procedures (VHTP), are inexpensively and easily performed. In addition, the performance measuring vehicle Comparison Variables (CV) for each VHTP are also provided.

Although good correlation between the HVHP and full-scale test data has been achieved, it is recommended that changes in all areas of the model, including the tire/road interface, the vehicle description, etc., be given serious consideration where an improvement in correlation could result. Also, since the HVHP has been proven adequate for the simulation of passenger vehicles, it is recommended that current plans to modify the HVHP mathematical model to allow the simulation of recreational and commercial vehicles be carried through to completion.

APPENDIX A

FOUR-WHEELED VEHICLE MATHEMATICAL MODEL

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FOUR-WHEELED VEHICLE MATHEMATICAL MODEL

1. INTRODUCTION

This Appendix contains the vehicle mathematical model which was implemented on the APL/JHU hybrid computer. A hybrid simulation block diagram is shown in Figure A-1.

2. SYSTEM EQUATIONS

2.1 Table of Contents

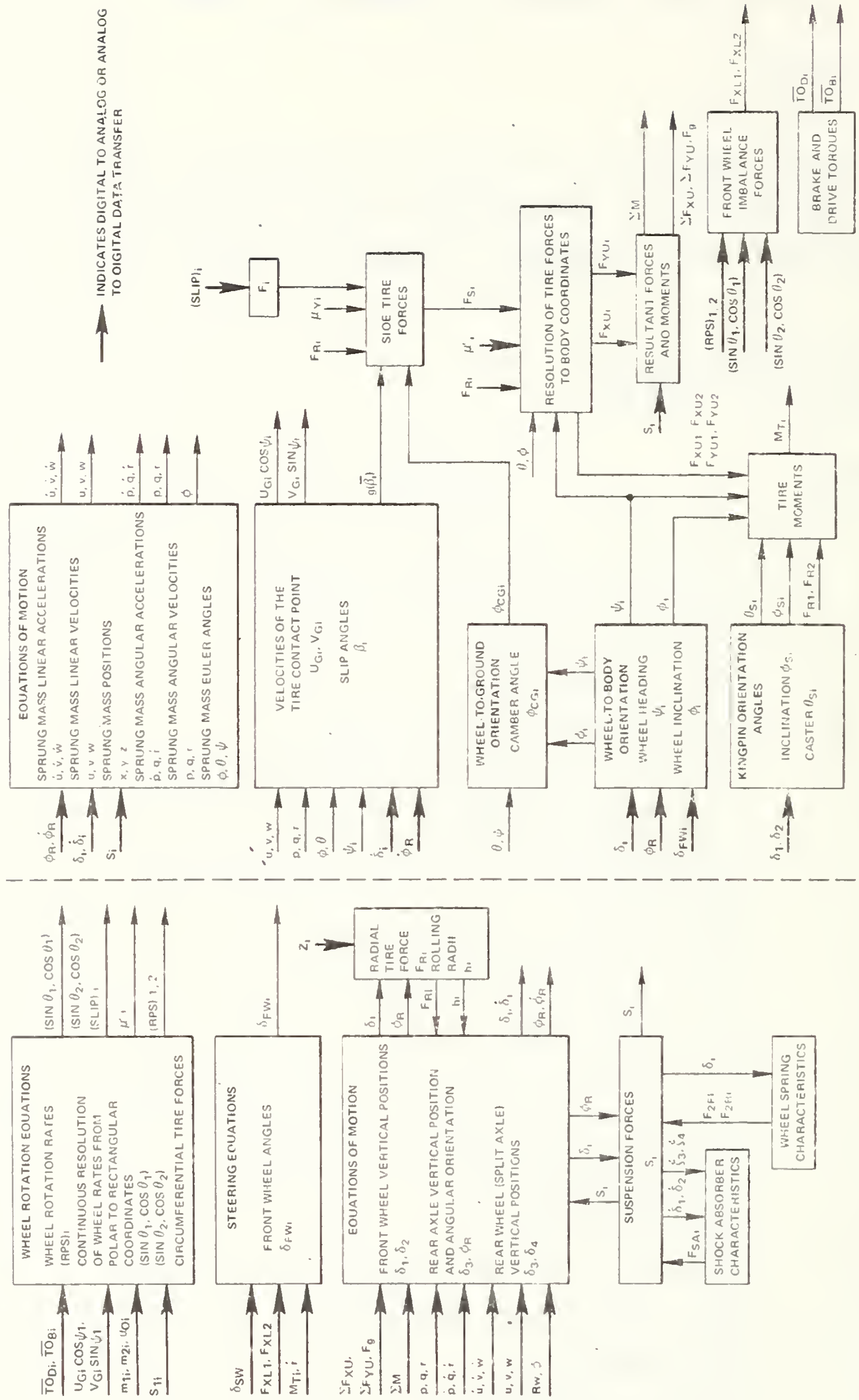

Fig. A-1 HYBRID SIMULATION BLOCK DIAGRAM OF THE AUTOMOBILE

2.2 Equations of Motion (Ten Degrees of Freedom)

The equations of motion of the sprung mass, front wheel unsprung masses, and rear axle are presented below:

$$(\Sigma M)\ \dot{u} + \gamma_2\ \dot{q} = (\Sigma M)\ (vr - wq - g\ \theta) + \Sigma F_{xu} \qquad (1)$$

$$(\Sigma M)\ \dot{v} - \gamma_2\ \dot{p} + \gamma_1\ \dot{r} = (\Sigma M)\ (wp - ur + g\ \phi) + \Sigma F_{yu} \qquad (2)$$

$$M_s\ \dot{w} = M_s\ (uq - vp + g) - \sum_{i=1}^{4} S_i \qquad (3)$$

$$-\gamma_3\ \dot{v} + (I_x + I_x')\ \dot{p} - (I_{xz}' + I_{xz})\ \dot{r} = \gamma_3\ (ur - wp - g\ \phi) + \Sigma N_{\phi u} \qquad (4)$$

$$\gamma_2\ \dot{u} + (I_y + I_y')\ \dot{q} = \gamma_2\ (vr - wq - g\ \theta) + \Sigma N_{\theta u} \qquad (5)$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_R + I_z')\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma N_{\psi u} \qquad (6)^*$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_z')\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma N_{\psi u} \qquad (7)^{**}$$

$$\frac{M_{uF}}{2}\ \dot{w} + \frac{M_{uF}\ T_F}{4}\ \dot{p} - \frac{M_{uF}\ a}{2}\ \dot{q} + \frac{M_{uF}}{2}\ \ddot{\delta}_1 = \frac{M_{uF}}{2}\ (uq - vp + g) + F_{zu1} + S_1 - F_{yu1}\ \mathrm{TAN}\left(\frac{2H_{FC}}{T_F}\right) \qquad (8)$$

*Solid Rear Axle
**Split Rear Axle

$$\frac{M_{uF}}{2}\dot{w} - \frac{M_{uF}\,T_F}{4}\dot{p} - \frac{M_{uF}\,a}{2}\dot{q} + \frac{M_{uF}}{2}\ddot{\delta}_2$$

$$= \frac{M_{uF}}{2}(uq - vp + g) + F_{zu2} + S_2$$

$$+ F_{yu2}\ \mathrm{TAN}\left(\frac{2H_{FC}}{T_F}\right) \qquad (9)$$

$$M_{uR}\dot{w} + b\,M_{uR}\dot{q} + \ddot{\delta}_3 M_{uR} = M_{uR}(uq - vp + g)$$

$$+ F_{zu3} + F_{zu4} + S_3 + S_4 \qquad (10)*$$

$$I_R\dot{p} + I_R\ddot{\phi}_R = \Sigma N_{\phi R} - (F_{yu3} + F_{yu4})\,H_{RC} \qquad (11)*$$

$$\frac{M_{uR}}{2}\dot{w} + \frac{M_{uR}\,b\dot{q}}{2} + \frac{M_{uR}\,T_R\,\dot{p}}{4} + \ddot{\delta}_3\frac{M_{uR}}{2}$$

$$= \frac{M_{uR}}{2}(uq - vp + g) + F_{zu3} + S_3$$

$$- F_{yu3}\ \mathrm{TAN}\left(\frac{2H_{RC}}{T_R}\right) \qquad (12)**$$

$$\frac{M_{uR}}{2}\dot{w} + \frac{M_{uR}}{2}b\dot{q} - \frac{M_{uR}\,T_R\,\dot{p}}{4} + \ddot{\delta}_4\frac{M_{uR}}{2}$$

$$= \frac{M_{uR}}{2}(uq - vp + g) + F_{zu4} + S_4$$

$$+ F_{yu4}\ \mathrm{TAN}\left(\frac{2H_{RC}}{T_R}\right) \qquad (13)**$$

where

$$\Sigma M = M_s + M_{uF} + M_{uR} \qquad (14)$$

$$I_x' = M_{uF}\,z_F^2 + M_{uR}\,z_R^2 \qquad (15)$$

*Solid Rear Axle
**Split Rear Axle

$$I_y' = I_x' \tag{16}$$

$$I_z' = M_{uF}\ (a^2 + \frac{T_F 2}{4}) + M_{uR}\ b^2 \quad (17)*$$

$$I_z' = M_{uF}\left(a^2 + \frac{T_F 2}{4}\right) + M_{uR}\left(b^2 + \frac{T_R 2}{4}\right) \quad (18)**$$

$$I_{xz}' = M_{uF}\ a\ z_F - M_{uR}\ b\ z_R \tag{19}$$

$$\gamma_1 = M_{uF}\ a - M_{uR}\ b \tag{20}$$

$$\gamma_2 = M_{uF}\ z_F + M_{uR}\ z_R \tag{21}$$

$$\gamma_3 = \gamma_2 \tag{22}$$

2.3 Vehicle Attitude and Position

The Euler angles and x, y, z coordinates in fixed space of the sprung mass are computed by the following equations:

$$\phi = \int_o^t (p + r\theta)\ dt + \phi(o) \tag{23}$$

$$\theta = \int_o^t (q - r\phi)\ dt + \theta(o) \tag{24}$$

$$\Psi = \int_o^t (r + q\phi)\ dt + \Psi(o) \tag{25}$$

$$x = \int_o^t (u\ \mathrm{COS}\ \Psi - v\ \mathrm{SIN}\ \Psi)\ dt + x(o) \tag{26}$$

$$y = \int_o^t (u\ \mathrm{SIN}\ \Psi + v\ \mathrm{COS}\ \Psi)\ dt + y(o) \tag{27}$$

$$z = \int_o^t (-u\theta + v\phi + w)\ dt + z(o) \tag{28}$$

*Solid Rear Axle
**Split Rear Axle

2.4 Suspension Forces

Suspension forces, including effects of viscous and coulomb damping, suspension stops, auxiliary roll stiffness, anti-pitch and anti-roll for front and rear are presented below:

For i = 1, 2 (Front)

$$S_i = \frac{b}{2(a+b)} M_s g - F_{1Fi} - F_{2Fi} - F_{3Fi} - (-1)^i \frac{R_F(\delta_2 - \delta_1)}{T_F^2} + A_{pi}(\delta_i) + A_{Ri}(\delta_i) \qquad (29)$$

where

$$F_{1Fi} = C_F' \operatorname{sgn} \dot{\delta}_i \qquad (30)$$

$$F_{2Fi} = K_{Fi}\,\delta_i + F_{BSi} \qquad (31)$$

$$F_{BSi} = K_{Fi}(\lambda_{Fc} - 1)(\delta_{Si} - \Omega_{Fc}), \delta_{Si} < \Omega_{Fc} \qquad (32)$$

$$= K_{Fi}\,\delta_i + K_{Fi}(\lambda_{FT} - 1)(\delta_{Si} - \Omega_{FT}), \delta_{Si} > \Omega_{FT} \qquad (33)$$

$$= 0 \qquad \text{otherwise}$$

where

$$\delta_{Si} = \delta_i + \delta_{FIN} \qquad (34)$$

$$\begin{aligned} F_{3Fi} &= C_1 \dot{\delta}_i + \left|C_2 - C_1\right| \dot{\delta}_{(A)}, & \dot{\delta}_i &< \dot{\delta}_{(A)} \\ &= C_2 \dot{\delta}_i, & \dot{\delta}_{(A)} &\le \dot{\delta}_i < 0 \\ &= C_3 \dot{\delta}_i, & 0 &\le \dot{\delta}_i \le \dot{\delta}_{(B)} \\ &= C_4 \dot{\delta}_i - \left|C_4 - C_3\right| \dot{\delta}_{(B)}, & \dot{\delta}_i &> \dot{\delta}_{(B)} \end{aligned} \qquad (35)$$

$$A_{pi}(\delta_i) = (P_{Fo} + P_{F1}\,\delta_i + P_{F2}\,\delta_i^2)\,F_{xui} \tag{36}$$

$$A_{Ri}(\delta_i) = (R_{Fo} + R_{F1}\,\delta_i + R_{F2}\,\delta_i^2)\,F_{yui} \tag{37}$$

$$S_i = \frac{a}{2(a+b)} M_s\,g - F_{1Ri} - F_{2Ri} - F_{3Ri} + (-1)^i \left[\frac{R_R\,\phi_R}{T_s}\right] + A_{pi}(\delta_i) + A_{Ri}(\delta_i) \tag{38)*}$$

$$S_i = \frac{a}{2(a+b)} M_s\,g - F_{1Ri} - F_{2Ri} - F_{3Ri} + (-1)^{i-1} \left[\frac{R_R}{T_R{}^2}\right](\delta_4-\delta_3) + A_{pi}(\delta_i) + A_{Ri}(\delta_i) \tag{39)**}$$

$$F_{1Ri} = C_R' \operatorname{sgn} \dot{\zeta}_i \tag{40}$$

For $i = 3, 4$ (Rear)

$$F_{2Ri} = K_{Ri}\,\zeta_i + F_{BSi} \tag{41}$$

$$F_{BSi} = K_{Ri}\,(\lambda_{RC} - 1)\,(\zeta_{si} - \Omega_{RC}), \quad \zeta_{si} < \Omega_{RC} \tag{42}$$

$$= K_{Ri}\,(\lambda_{RT} - 1)\,(\zeta_{si} - \Omega_{RT}), \quad \zeta_{si} > \Omega_{FT} \tag{43}$$

$$= 0 \qquad \text{otherwise}$$

where

$$\zeta_{si} = \zeta_i + \delta_{RIN} \tag{44}$$

$$F_{3Ri} = D_1\,\dot{\zeta}_i + |D_2 - D_1|\,\dot{\zeta}_{(A)}, \quad \dot{\zeta}_i < \dot{\zeta}_{(A)} \tag{45}$$

$$= D_2\,\dot{\zeta}_i, \qquad \dot{\zeta}_{(A)} \le \dot{\zeta}_i < 0$$

$$= D_3\,\dot{\zeta}_i, \qquad 0 \le \dot{\zeta}_i < \dot{\zeta}_{(B)}$$

*Solid Rear Axle
**Split Rear Axle

$$= D_4 \dot{\zeta}_i - |D_4 - D_3| \dot{\zeta}_{(B)} \ , \ \dot{\zeta}_i > \dot{\zeta}_{(B)}$$

where

$\dot{\delta}_{(A)}, \dot{\delta}_{(B)}, \dot{\zeta}_{(A)}, \dot{\zeta}_{(B)}$ = non-zero break points on the restoring force characteristic.

$C_1, C_2, C_3, C_4, D_1, D_2, D_3, D_4$ = slope of four-line segments representing the restoring force characteristic.

and

$$\zeta_3 = \frac{T_s}{2} \phi_R + \delta_3 \qquad (46)^*$$

$$\dot{\zeta}_3 = \frac{T_s}{2} \dot{\phi}_R + \dot{\delta}_3 \qquad (47)^*$$

$$\zeta_4 = - \frac{T_s}{2} \phi_R + \delta_3 \qquad (48)^*$$

$$\dot{\zeta}_4 = - \frac{T_s}{2} \dot{\phi}_R + \dot{\delta}_3 \qquad (49)^*$$

$$\zeta_3 = \delta_3 \qquad (50)^{**}$$

$$\dot{\zeta}_3 = \dot{\delta}_3 \qquad (51)^{**}$$

$$\zeta_4 = \delta_4 \qquad (52)^{**}$$

$$\dot{\zeta}_4 = \dot{\delta}_4 \qquad (53)^{**}$$

$$A_{pi}(\delta_i) = (P_{Ro} + P_{R1} \delta_i + P_{R2} \delta_i^2) F_{xui} \qquad (54)$$

*Solid Rear Axle
**Split Rear Axle

$$A_{Ri}(\delta_i) = (R_{R0} + R_{R1}\,\delta i + R_{R2}\,\delta_i^2)\;F_{yui} \tag{55}$$

2.5 Wheel Orientation

The orientations of the wheels with respect to the sprung mass are defined by the following equations:

$$\phi_1 = \sum_{i=o}^{6} C_{iF}\,\delta_{S1}^{i} + \Delta\phi_1 \text{ sgn } F_{S1} \tag{56}$$

$$\phi_2 = -\sum_{i=o}^{6} C_{iF}\,\delta_{S2}^{i} + \Delta\phi_2 \text{ sgn } F_{S2} \tag{57}$$

$$\phi_3 = \sum_{i=o}^{6} C_{iR}\,\zeta_{S3}^{i} \tag*{(58)**}$$

$$\phi_4 = -\sum_{i=o}^{6} C_{iR}\,\zeta_{S4}^{i} \tag*{(59)**}$$

$$\phi_3 = \phi_4 = \phi_R \tag*{(60)*}$$

$$\Psi_1 = \delta_{FW1} + \sum_{i=o}^{6} D_{iF}\,\delta_{S1}^{i} + \varepsilon_{K1} \tag{61}$$

$$\Psi_2 = \delta_{FW2} - \sum_{i=o}^{6} D_{iF}\,\delta_{S2}^{i} + \varepsilon_{K2} \tag{62}$$

$$\Psi_3 = K_{RS}\,\phi_R + K_{SR}\,M_{ZR} \tag*{(63)*}$$

$$\Psi_4 = \Psi_3 \tag*{(64)*}$$

$$\Psi_3 = \sum_{i=o}^{6} D_{iR}\,\zeta_{S3}^{i} + K_{SR}\,M_{ZR} \tag*{(65)**}$$

$$\Psi_4 = -\sum_{i=o}^{6} D_{iR}\,\zeta_{S4}^{i} + K_{SR}\,M_{ZR} \tag*{(66)**}$$

$$\theta_{S1} = \sum_{i=o}^{6} E_{iF}\,\delta_{S1}^{i} + \Delta\theta_1 \tag{67}$$

*Solid Rear Axle
**Split Rear Axle

$$\theta_{S2} = \sum_{i=o}^{6} E_{iF}\, \delta_{S2}^{i} + \Delta\theta_2 \tag{68}$$

2.6 Resultant Forces and Moments

The resultant tire and suspension forces and moments, including the anti-pitch and wheel imbalance, as required for the equations of motion are given below.

Forces:

$$\Sigma F_{xu} = \sum_{i=1}^{4} F_{xui} \tag{69}$$

$$F_{xui} = F_{Ri}\, \theta + F_{Ci} \text{ COS } \Psi_i - F_{Si} \text{ SIN } \Psi_i \tag{70}$$

$$\Sigma F_{yu} = \sum_{i=1}^{4} F_{yui} \tag{71}$$

$$F_{yui} = -F_{Ri}\, \phi + F_{Ci} \text{ SIN } \Psi_i + F_{Si} \text{ COS } \Psi_i \tag{72}$$

$$\Sigma F_{zu} = \sum_{i=1}^{4} F_{zui} \tag{73}$$

$$F_{zui} = -F_{Ri} \tag{74}$$

$$F_{XL1} = M_{L1}\, R_{RIM} \text{ RPS1 RPS1 COS } \theta_{L1} \tag{75}$$

$$F_{XL2} = M_{L2}\, R_{RIM} \text{ RPS2 RPS2 COS } \theta_{L2} \tag{76}$$

$$F_{ZL1} = M_{L1}\, R_{RIM} \text{ RPS1 RPS1 SIN } \theta_{L1} \tag{77}$$

$$F_{ZL2} = M_{L2}\, R_{RIM} \text{ RPS2 RPS2 SIN } \theta_{L2} \tag{78}$$

Moments:

$$\Sigma\ N_{\psi u} = (F_{yu1} + F_{yu2})\ a - (F_{yu3} + F_{yu4})\ b \qquad (79)$$

$$+ (F_{xu2} - F_{xu1}) \frac{T_F}{2} + (F_{xu4} - F_{xu3}) \frac{T_R}{2}$$

$$+ \sum_{i=1}^{2} M_{ZFi} + \sum_{i=3}^{4} M_{ZRi}$$

$$\Sigma\ N_{\phi u} = \frac{T_F}{2} (S_2 - S_1) + \frac{T_S}{2} (S_4 - S_3) \qquad (80)*$$

$$- F_{yu1} (Z_F + \delta_1 + h_1 - H_{FC})$$

$$- F_{yu2} (Z_F + \delta_2 + h_2 - H_{FC})$$

$$- (F_{yu3} + F_{yu4}) (\delta_3 + H_{RC} + Z_R) + \sum_{i=1}^{2} M_{XFi}$$

$$\Sigma\ N_{\theta u} = (S_1 + S_2)\ a - (S_3 + S_4)\ b \qquad (81)*$$

$$+ F_{xu1} (z_F + \delta_1 + h_1) + F_{xu2} (z_F + \delta_2 + h_2)$$

$$+ F_{xu3} \left(z_R + \delta_3 + \frac{T_R}{2} \phi_R + h_3\right)$$

$$+ F_{xu4} \left(z_R + \delta_3 - \frac{T_R}{2} \phi_R + h_4\right)$$

$$\Sigma\ N_{\phi u} = \frac{T_F}{2} (S_2 - S_1) + \frac{T_R}{2} (S_4 - S_3) \qquad (82)**$$

$$- F_{yu1} (Z_F + \delta_1 + h_1 - H_{FC})$$

$$- F_{yu2} (Z_F + \delta_2 + h_2 - H_{FC})$$

$$- F_{yu3} (Z_R + \delta_3 + h_3 - H_{RC})$$

$$- F_{yu4} (Z_R + \delta_4 + h_4 - H_{RC})$$

$$+ \sum_{i=1}^{2} M_{XFi} + \sum_{i=3}^{4} M_{XRi}$$

*Solid Rear Axle
**Split Rear Axle

$$\Sigma N_{\theta u} = (S_1 + S_2)\, a - (S_3 + S_4)\, b \tag{83}**$$
$$+ F_{xu1}\,(Z_F + \delta_1 + h_1) + F_{xu2}\,(Z_F + \delta_2 + h_2)$$
$$+ F_{xu3}\,(Z_R + \delta_3 + h_3) + F_{xu4}\,(Z_R + \delta_4 + h_4)$$

$$\Sigma N_{\phi R} = F_{zu3}\left(\frac{T_R}{2} - h_3\phi_R\right) - F_{zu4}\left(\frac{T_R}{2} + h_4\phi_R\right) \tag{84}*$$
$$- F_{yu3}\left(\frac{T_R}{2}\,\phi_R + h_3\right) - F_{yu4}\left(- \frac{T_R}{2}\,\phi_R + h_4\right)$$
$$+ (S_3 - S_4)\,\frac{T_S}{2} + \sum_{i=3}^{4} M_{XRi}$$

where M_{ZFi}, M_{ZRi}, M_{XFi} and M_{XRi} are the front and rear wheel aligning torques and overturning moments.

2.7 Radial Tire Force and Rolling Radius

The radial tire forces and the rolling radii of the tires are computed by the following equations:

$$F_{Ri} = K_{Ti}\,(R_W - h_i), \qquad (R_W - hi) > o \tag{85}$$
$$= 0, \qquad (R_W - hi) \leq o$$

where

$$h_i = - Z_i \;;\; i = 1,2,3,4$$

$$Z_1 = Z - a\,\theta + \frac{T_F}{2}\,\phi + Z_F + \delta_1 \tag{86}$$

$$Z_2 = Z - a\,\theta - \frac{T_F}{2}\,\phi + Z_F + \delta_2 \tag{87}$$

$$Z_3 = Z + b\,\theta + \frac{T_R}{2}\,\phi + Z_R + \frac{T_R}{2}\,\phi_R + \delta_3 \tag{88}*$$

$$Z_4 = Z + b\,\theta - \frac{T_R}{2}\,\phi + Z_R - \frac{T_R}{2}\,\phi_R + \delta_3 \tag{89}*$$

*Solid Rear Axle
**Split Rear Axle

$$Z_3 = Z + b\ \theta + \frac{T_R}{2}\ \phi + Z_R \div \delta_3 \tag{90)**}$$

$$Z_4 = Z + b\ \theta - \frac{T_R}{2}\ \phi + Z_R + \delta_4 \tag{91)**}$$

and the initial tire loading and orientation are as shown below:

$$\theta(0) = \frac{\left|h_{1(0)} - h_{3(0)}\right| \div \left|Z_F - Z_R\right|}{a+b}$$

$$h_{1(0)} = h_{2(0)} = R_w - \frac{g}{2K_{T1}}\left[M_{UF} + \left(\frac{b}{a+b}\right) M_S\right]$$

$$h_{3(0)} = h_{4(0)} = R_w - \frac{g}{2K_{T3}}\left[M_{UR} + \left(\frac{a}{a+b}\right) M_S\right]$$

$$Z_{(0)} = \frac{b\left|h_{1(0)} + Z_F\right| + a\left|h_{3(0)} + Z_R\right|}{a+b}$$

Wheel lift-off indication is provided by

$$Z_{MXi} = R_w - h_i \qquad i = 1,2,3,4 \tag{92}$$

where

$Z_{MXi} > o$ wheel i in contact with tire-terrain patch

$Z_{MXi} \leq o$ wheel i not in contact with tire-terrain patch

2.8 Tire Circumferential Force

The circumferential tire forces for both driving and braking are defined below:

$$F_{Ci} = - \mu_i' F_{Ri} \tag{93}$$

**Split Rear Axle

2.9 Circumferential Friction Coefficient

The circumferential friction coefficient equations are shown below:

$$\mu_i' = m_{2i}\ (\text{SLIP})_i + \mu_{0i} \quad \text{for } (\text{SLIP})_i > SI_i \tag{94}$$

$$= m_{1i}\ (\text{SLIP})_i \quad \text{for } (\text{SLIP})_i \leq SI_i$$

Computation of the slopes for the μ_i' curve is performed by the following equations:

$$m_{1i} = \left(\frac{\mu_{PF}}{SI_i}\right)(1.0 - 0.03|\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{95}$$

$$= \mu_{SF}\ SN_i \qquad m_{1i} < \mu_{SF}$$

$$m_{2i} = \frac{(\mu_{SF} - \mu_{PF})}{(1.0 - SI_i)}(1.0 - 0.06|\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{96}$$

$$= \mu_{SF}\ SN_i \qquad m_{2i} \geq \mu_{SF}$$

$$\mu_{PF} = P_{BF1} + P_{BF2}\ F_{Ri} \tag{97}$$

$$\mu_{1i} = \mu_{SF}\ SNi \tag{98}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \qquad i = 1,2 \tag{99}$$

$$m_{1i} = \left(\frac{\mu_{PR}}{SI_i}\right)(1.0 - 0.03\ |\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{100}$$

$$= \mu_{SR}\ SN_i \qquad m_{1i} < \mu_{SR}$$

$$m_{2i} = \frac{(\mu_{SR} - \mu_{PR})}{(1.0 - SI_i)}(1.0 - 0.06\ |\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{101}$$

$$\mu_{SR}\ SN_i \qquad m_{2i} \geq \mu_{SR}$$

$$\mu_{PR} = P_{BR1} + P_{BR2}\ F_{Ri} \tag{102}$$

$$\mu_{1i} = \mu_{SR}\, SN_i \tag{103}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \qquad\qquad i = 3,4 \tag{104}$$

$$SN_i = S_{NSO}/S_{NT} \tag{105}$$

2.10 Wheel Slip

Computation of circumferential wheel slip is performed by the following equations:

$$\begin{aligned}(SLIP)_i &= 1 \quad \text{for } \xi_i > 1 \\ &= \xi_i \text{ for } -1 \leq \xi_i \leq 1 \\ &= -1 \text{ for } \xi_i < -1\end{aligned} \tag{106}$$

where

$$\xi_i = 1 - \frac{(RPS)_i\, h_i}{u_{Gi} \cos \Psi_i + v_{Gi} \sin \Psi_i}, \qquad \overline{TQ}_{\beta i} \geq 0 \tag{107}$$

2.11 Wheel Rotational Equations

The wheel rotational equations required to compute wheel slip are presented below:

$$I_{WF} \left[\frac{d}{dt} (RPS)_1\right] = -F_{C1}\, h_1 + \overline{TQ}_1\, \lambda_{B1} \tag{108}$$

$$I_{WF} \left[\frac{d}{dt} (RPS)_2\right] = -F_{C2}\, h_2 + \overline{TQ}_2\, \lambda_{B2} \tag{109}$$

$$\left[I_{WR} + \frac{I_D\, (\overline{AR})^2}{4}\right] \left[\frac{d}{dt} (RPS)_3\right] + \left[\frac{I_D\, (\overline{AR})^2}{4}\right] \left[\frac{d}{dt} (RPS)_4\right] = -F_{C3}\, h_3 + \overline{TQ}_3\, \lambda_{B3} \tag{110}$$

$$\left[\frac{I_D\ (\overline{AR})^2}{4}\right]\left[\frac{d}{dt}\ (RPS)_3\right] + \left[I_{WR} + \frac{I_D\ (\overline{AR})^2}{4}\right]\left[\frac{d}{dt}\ (RPS)_4\right]$$

$$= -F_{C4}\ h_4 + \overline{TQ}_4\ \lambda_{B4} \tag{111}$$

where

$$(RPS)_i = (RPS)_{io} + \int_o^t \frac{d}{dt}\ \left[(RPS)_i\right] dt \tag{112}$$

For $(SLIP)_i = 0$ at $t = 0$

$$(RPS)_{io} = \frac{u_{Gi}(o)\ COS\ \Psi_i(o) + v_{Gi}(o)\ SIN\ \Psi_i(o)}{h_i(o)} \tag{113}$$

and where

$$\overline{TQ}_1 = \overline{TQ}_{B1} \tag{114}$$

$$\overline{TQ}_2 = \overline{TQ}_{B2} \tag{115}$$

$$\overline{TQ}_3 = \frac{\overline{AR}}{2}\ \overline{TQ}_D + \overline{TQ}_{B3} \tag{116}$$

$$\overline{TQ}_4 = \frac{\overline{AR}}{2}\ \overline{TQ}_D + \overline{TQ}_{B4} \tag{117}$$

2.12 Brake and Drive Torques

The drive torques generated to maintain a constant velocity are computed by:

$$\overline{TQ}_D = K_{TQ}\ (V_C - u),\ \text{for } \overline{TQ}_D \leq TQ_{D_{MAX}} \tag{118}$$

$$= TQ_{D_{MAX}}\ ,\quad \text{otherwise} \tag{119}$$

where V_C is the desired velocity.

Values of 1000 in-lb/in/sec and 6000 in-lb were assigned to K_{TQ} and TQ_{DMAX} respectively. When braking is

investigated, the drive torque is zero and the brake torque magnitudes are determined from input data functions.

$$\overline{TQ}_{B1} = \overline{TQ}_{B2} = FF(PFL), \text{ in-lbs} \tag{120}$$

$$\overline{TQ}_{B3} = \overline{TQ}_{B4} = FR(PFL), \text{ in-lbs} \tag{121}$$

where PFL is an input value for brake-line pressure.

2.13 Tire Side Force

The nonlinear tire side forces are computed using the following equation:

$$F_{Si} = \mu_{yi} F_{Ri} \left[g\ (\overline{\beta}_i)\right] \left[F_i\ (SLIP_i)\right] \tag{122}$$

2.14 Tire Side Force Friction Coefficient

The side force coefficient of friction is defined below:

$$\mu_{yi} = (B_1 F_{Ri} + B_2 C_{vi} + B_3 + B_4 F_{Ri}^2)\ SN_i \qquad i = 1,2 \tag{123}$$

$$\mu_{yi} = (RB_1 F_{Ri} + RB_2 C_{vi} + RB_3 + RB_4 F_{Ri}^2)\ SN_i \qquad i = 3,4 \tag{124}$$

and

$$C_{vi} = \sqrt{u_{Gi}^2 + v_{Gi}^2} \tag{125}$$

2.15 Velocities of the Tire Contact Points

The velocities of the tire contact points along the vehicle axes are computed by the following equations:

$$u_1 = u - \frac{T_F}{2} r + z_F q \tag{126}$$

$$u_2 = u + \frac{T_F}{2} r + z_F q \tag{127}$$

$$u_3 = u - \frac{T_R}{2} r + z_R q \tag{128}$$

$$u_4 = u + \frac{T_R}{2} r + z_R q \tag{129}$$

$$v_1 = v + ar - z_F p - h_1 p \tag{130}$$

$$v_2 = v + ar - z_F p - h_2 p \tag{131}$$

$$v_3 = v - br - z_R p - h_3 (p + \dot{\phi}_R) \tag{132)*}$$

$$v_3 = v - br - z_R p - h_3 p \tag{133)**}$$

$$v_4 = v - br - z_R p - h_4 (p + \dot{\phi}_R) \tag{134)*}$$

$$v_4 = v - br - z_R p - h_4 p \tag{135)**}$$

$$w_1 = w - aq + \frac{T_F}{2} p + \dot{\delta}_1 \tag{136}$$

$$w_2 = w - aq - \frac{T_F}{2} p + \dot{\delta}_2 \tag{137}$$

$$w_3 = w + bq + \dot{\delta}_3 + \frac{T_R}{2} (\dot{\phi}_R + p) \tag{138)*}$$

$$w_3 = w + bq + \dot{\delta}_3 + \frac{T_R}{2} p \tag{139)**}$$

$$w_4 = w + bq + \dot{\delta}_3 - \frac{T_R}{2} (\dot{\phi}_R + p) \tag{140)*}$$

$$w_4 = w + bq + \dot{\delta}_4 - \frac{T_R}{2} p \tag{141)**}$$

*Solid Rear Axle
**Split Rear Axle

The wheel velocities in the ground plane are obtained by:

$$u_{Gi} = u_i + \theta w_i \tag{142}$$

$$v_{Gi} = v_i - \phi w_i \tag{143}$$

2.16 Combined Slip Angle and Camber Shaping Function

The dimensionless side force shaping function for slip angle and camber is as follows:

$$g(\overline{\beta}_i) = \overline{\beta}_i - \frac{1}{3}\overline{\beta}_i \left|\overline{\beta}_i\right| + \frac{1}{27}\overline{\beta}_i^{\,3} \quad \text{if } \left|\overline{\beta}_i\right| < 3 \tag{144}$$

$$= \frac{\overline{\beta}_i}{\left|\overline{\beta}_i\right|} \quad \text{if } \left|\overline{\beta}_i\right| \geq 3 \qquad i = 1,2,3,4$$

where $\overline{\beta}_i$ is defined by

For $F_{Ri} \leq A\Omega_T A_2$,

$$i = 1,2$$

$$\overline{\beta}_i = \frac{A_1 F_{Ri} (F_{Ri} - A_2) - A_o A_2}{A_2 \mu_{yi} F_{Ri}} (\beta_i + \beta_i') \tag{145}$$

$$\beta_i' = \frac{A_2 A_3 (A_4 - F_{Ri}) F_{Ri} \phi_{CGi}}{A_4 \left|A_1 F_{Ri} (F_{Ri} - A_2) - A_o A_2\right|} \tag{146}$$

If $F_{Ri} > A\Omega_T A_2$,

$$i = 1,2$$

$$\overline{\beta}_i = \frac{A_1 A_2 A\Omega_T (A\Omega_T - 1) - A_o}{\mu_{yi} F_{Ri}} (\beta_i + \beta_i') \tag{147}$$

$$\beta_i' = \frac{A_2 A_3 A\Omega_T (A_4 - A\Omega_T A_2) \phi_{CGi}}{A_4 \left|A_1 A_2 A\Omega_T (A\Omega_T - 1) - A_o\right|} \tag{148}$$

For $F_{Ri} \leq R\Omega_T\ RA_2$, $\quad i = 3,4$

$$\overline{\beta}_i = \frac{RA_1\ F_{Ri}\ (F_{Ri} - RA_2) - RA_o\ RA_2}{RA_2\ \mu_{yi}\ F_{Ri}}\ (\beta_i + \beta_i') \tag{149}$$

$$\beta_i' = \frac{RA_2\ RA_3\ (RA_4 - F_{Ri})\ F_{Ri}\ \phi_{CGi}}{RA_4\ \left[RA_1\ F_{Ri}\ (F_{Ri} - RA_2) - RA_o\ RA_2\right]} \tag{150}$$

If $F_{Ri} > R\Omega_T\ RA_2$, $\quad i = 3,4$

$$\overline{\beta}_i = \frac{RA_1\ RA_2\ R\Omega_T\ (R\Omega_T - 1) - RA_o}{\mu_{yi}\ F_{Ri}}\ (\beta_i + \beta_i') \tag{151}$$

$$\beta_i' = \frac{RA_2\ RA_3\ R\Omega_T\ (RA_4 - R\Omega_T\ RA_2)\ \phi_{CGi}}{RA_4\ \left[RA_1\ RA_2\ R\Omega_T\ (R\Omega_T - 1) - RA_o\right]} \tag{152}$$

2.17 Wheel Slip Angle

$$\beta_i = \tan^{-1}\left[\frac{v_{Gi}}{|u_{Gi}|}\right] - \Psi_i\ \mathrm{sgn}\ u_{Gi} \tag{153}$$

2.18 Wheel Camber with Respect to the Road

The camber angles of the wheels measured with respect to the road are given by:

$$\phi_{CGi} = \theta\ \mathrm{SIN}\ \Psi_i + \phi\ \mathrm{COS}\ \Psi_i + \phi_i + K_{CF}\ F_{Si} \quad i = 1,2 \tag{154}$$

$$\phi_{CGi} = \theta\ \mathrm{SIN}\ \Psi_i + \phi\ \mathrm{COS}\ \Psi_i + \phi_i + K_{CR}\ F_{Si} \quad i = 3,4 \tag{155}**$$

$$\phi_{CGi} = 0;\ i = 3,4 \tag{156}*$$

*Solid Rear Axle
**Split Rear Axle

2.19 Wheel Slip Shaping Function

The dimensionless side force shaping function for circumferential slip is empirically derived.

$$F_i\ (SLIP_i) = \text{input table} \tag{157}$$

F_i	$SLIP_i$ (%)
1.00	0.0
0.99	5.0
0.97	10.0
0.93	15.0
0.86	20.0
0.72	30.0
0.56	40.0
0.34	60.0
0.25	80.0
0.18	100.0

2.20 Tire Moments

The tire-road reaction moments acting about the kingpins are computed by the following equations:

$$\begin{aligned} M_{Ti} = {} & F_{xui} \Big[\overline{PT}_i\ \text{SIN}\ \Psi_i - y_{SAi}\ \text{COS}\ \Psi_i \\ & + h_i\ (\phi_i\ \text{COS}\ \Psi_i - \phi_{Si})\Big] + F_{yui} \Big[-\overline{PT}_i\ KK_i\ \text{COS}\ \Psi_i \\ & - y_{SAi}\ \text{SIN}\ \Psi_i + h_i\ (\phi_i\ \text{SIN}\ \Psi_i - \theta_{Si})\Big] \\ & + F_{zui} \Big[-\overline{PT}_i\ (\phi_{Si}\ \text{COS}\ \Psi_i + \theta_{Si}\ \text{SIN}\ \Psi_1) \\ & + y_{SAi}\ (\theta_{Si}\ \text{COS}\ \Psi_i - \phi_{Si}\ \text{SIN}\ \Psi_i) \\ & + h_i\ (\phi_{Si}\ \phi_i\ \text{SIN}\ \Psi_i - \theta_{Si}\ \phi_i\ \text{COS}\ \Psi_i)\Big] + M_{ZF} \\ & - F_{XLi}\ (Y_{SAi} + \frac{R_{WR}}{2})\ ; \qquad i = 1,2 \end{aligned} \tag{158}$$

$$\phi_{S1} = \phi_{SA1} + \phi_1 \tag{159}$$

$$\phi_{S2} = \phi_{SA2} + \phi_2 \tag{160}$$

The tire aligning torques are defined as

$$M_{ZFi} = (AF_1\, F_{Ri} + AF_2\, |F_{Si}|)\, F_{Si} + AF_3\, F_{Ri}\, (\phi_{CGi})^{\frac{1}{2}} \qquad (161)$$

$i = 1,2$

$$M_{ZRi} = (AR_1\, F_{Ri} + AR_2\, |F_{Si}|)\, F_{Si} + AR_3\, F_{Ri}\, (\phi_{CGi})^{\frac{1}{2}} \qquad (162)$$

$i = 3,4$

The tire overturning moments are defined as

$$M_{XFi} = OF_0 + (OF_1 + OF_2\, \phi_{CGi})\, F_{Si}\, F_{Ri} + OF_3\, \phi_{CGi}\, F_{Ri} \qquad (163)$$

$i = 1,2$

$$M_{XRi} = OR_0 + (OR_1 + OR_2\, \phi_{CGi})\, F_{Si}\, F_{Ri} + OR_3\, \phi_{CGi}\, F_{Ri} \qquad (164)$$

$i = 3,4$

2.21 Steering Equations

The steering equations are presented below:

$$(\dot{r} + \ddot{\delta}_{FWi})\, I_{FW} = -H_i\, \dot{\delta}_{FWi} + M_{Ti} - M_{SSi} \qquad (165)$$

$i = 1,2$

$$M_{CR}\, \ddot{y}_{CR} = -C_{FCR} - C_{CR}\, \dot{y}_{CR} + \frac{T_p}{a_p} + \frac{M_{SS1}}{a_{L1}} + \frac{M_{SS2}}{a_{L2}} \qquad (166)$$

where $C_{FCR} = f(\dot{y}_{CR})$

conditions:

$$T_p = N_G\, \{K_{SC}\, (\delta_{SW} - N_G\, \frac{Y_{CR}}{a_p} - \frac{\varepsilon_{SP}}{2}\, \mathrm{sgn}\, \delta_{SW})\} \qquad (167)$$

if $\left|\delta_{SW} - N_G\, \frac{Y_{CR}}{a_p}\right| > \frac{\varepsilon_{SP}}{2}$

otherwise $T_p = 0$

$$M_{SSi} = K_{SLi} \left[\left(\delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right) - \frac{\varepsilon_{pi}}{2} \operatorname{sgn} \delta_{FWi} \right] \tag{168}$$

$$\text{if} \quad \left| \delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right| > \frac{\varepsilon_{pi}}{2}$$

otherwise $M_{SSi} = 0$

2.22 Longitudinal and Lateral Accelerations

The longitudinal and lateral accelerations of the sprung mass are computed by the following equations:

$$A_x = \dot{u} - vr + wq \tag{169}$$

$$A_y = \dot{v} + ru - wp \tag{170}$$

3. NOTATION AND LIST OF SYMBOLS

3.1 Notation

The time derivative of a variable is indicated by a dot over the symbol for the variable $\left(\text{i.e., } \dot{\delta} = \frac{d\delta}{dt}, \ddot{\delta} = \frac{d^2\delta}{dt^2}.\right)$

Also: 1 degree = 0.0174532925 radians

1 g = 386.4 in/sec^2

The following subscript notation is employed:

F = front
R = rear, or rear axle
s = sprung mass
u = unsprung mass
i = wheel number, 1 - right front, 2 - left front, 3 - right rear, 4 - left rear

3.2 List of Symbols

a,b = distances along the vehicle fixed x_B axis from the sprung mass center of gravity to the spin axes of the front and rear wheels, respectively, in.

AF_1, AF_2, AF_3 = front wheel aligning torque function coefficients.

a_{Li} = length of steering linkage arm, in. - i = 1,2

a_p = length of pitman arm, in.

A_{pi} = anti-pitch forces in front and rear suspensions, lb.

$\overline{AR}$ = drive axle ratio.

A_{Ri} = anti-roll forces in front and rear suspensions, lb.

AR_1, AR_2, AR_3 = rear wheel aligning torque function coefficients.

A_x = longitudinal acceleration of the sprung mass, gees.

A_y = lateral acceleration of the sprung mass, gees.

A_0, A_1, A_2 = coefficients in quadratic cornering stiffness function for a pneumatic tire, front.

A_3, A_4 = coefficients in quadratic camber stiffness function for a pneumatic tire, front.

$A\Omega_T$, $R\Omega_T$ = multiple of A_2 and RA_2 at which the assumed parabolic variations of small-angle cornering and camber stiffness with tire loading are made constant.

B_1, B_2, B_3, B_4 = constant coefficients for curves fitted to the lateral friction coefficient properties, front tires.

C_{CR} = viscous damping coefficient of steering system connecting rod, lb-sec/in.

C_{FCR} = coulomb damping coefficient of steering system connecting rod, lb.

C_F, C_R = viscous damping coefficient for a single wheel, effective at the wheel for the front and at the spring for the rear suspension, at the front and rear, respectively, lb-sec/in.

C_F', C_R' = coulomb damping for a single wheel, effective at the wheel for the front and at the spring for the rear suspension, at the front and rear, respectively, lb.

C_{iF}, C_{iR} = coefficients for wheel camber angle versus suspension deflection polynominal function, front and rear, respectively, i = 1, ..., 6.

C_{vi} = total contact point velocity of wheel i, in/sec.

D_{iF}, D_{iR} = coefficients for wheel toe angle versus suspension deflection polynominal function, front and rear, respectively, i = 1, ..., 6.

E_{iF} = coefficients for front wheel caster angle versus suspension deflection polynominal function, i = 1, ..., 6.

F_{BSi} = suspension forces increment produced by spring deflections at compression and rebound bump stops, lb.

F_{Ci} = circumferential tire force at wheel i, lb.

FF, FR = front and rear brake torque curves which are input as functions of brake line pressure, in - lb.

F_i = side force shaping function for braking slip.

F_{Ri} = radial tire force at wheel i, lb.

F_{Si} = lateral tire force at wheel i, lb.

F_{XLi}, F_{ZLi} = unbalanced forces on front wheel due to wheel imbalance, lb.

F_{xui}, F_{yui}, F_{zui} = components of the tire force on wheel i in the body coordinate system, lb.

ΣF_{xu}, ΣF_{yu}, ΣF_{zu} = summation of the forces acting on the sprung mass along the vehicle X_B, Y_B and Z_B axes, lb.

F_{1Fi}, F_{1Ri} = coulomb damping forces in front and rear suspensions, at an individual wheel, effective at wheels in front and at spring locations in rear, lb.

F_{2Fi}, F_{2Ri} = suspension forces produced by deflection of springs and elastic travel limits, lb.

F_{3Fi}, F_{3Ri} = coulomb damping forces in front and rear suspensions, at an individual wheel, effective at wheels in front and at spring locations in rear, lb.

F_{2Fi}, F_{2Ri} = suspension forces produced by deflection of springs and elastic travel limits, lb.

F_{3Fi}, F_{3Ri} = viscous suspension damping force due to shock absorbers, effective at wheel i, lb.

g = acceleration of gravity.

$g(\overline{\beta}_i)$ = side force shaping function for combined slip angle and camber angle at wheel i.

H_{FC} = distance between ground and roll center of front suspension, in.

h_i = rolling radius of wheel i, in.

H_i = front wheel viscous damping coefficient, in-lb/rad/sec.

H_{RC} = distance between center of rear axle and roll center of rear suspension, in.

I_D = drive line moment of inertia about its spin axis, lb-sec^2-in.

I_{FW} = moment of inertia of one front wheel about the kingpin axis, lb-sec^2-in.

I_R = rear unsprung mass moment of inertia about a line through its center of gravity and parallel to the X_B axis, lb-sec^2-in.

I_{Wj} = rotational inertia of individual wheel about its spin axis, at front and rear (j = F, R), respectively, lb-sec^2-in.

I_x = moment of inertia of sprung mass about the X_B axis. lb-sec^2-in.

I_y = moment of inertia of sprung mass about the Y_B axis, lb-sec^2-in.

I_z = moment of inertia of sprung mass about the Z_B axis, lb-sec^2-in.

I_{xz} = product of inertia of sprung mass about the X_B, Z_B axes, lb-sec^2-in.

I_x', I_y', I_z', I_{xz}' = moments of inertia of unsprung masses, lb-sec^2-in.

K_{CF}, K_{CR} = front and rear lateral compliance camber coefficients, respectively.

K_{Fi}, K_{Ri} = suspension load-deflection rate for a single wheel in the quasi-linear range about the design position, effective at the wheel for the front and at the spring for the rear suspension, at the front and rear, respectively, lb/in.

K_{RS} = roll steer gain of rear wheels relative to the vehicle coordinate system, rad/rad.

K_{SC} = steering column-gear box flexibility, in-lbs/rad.

K_{SLi} = steering linkage flexibility between the output of the steering unit and the kingpin, in-lb/rad. i = 1,2

K_{SR} = rear aligning torque compliance steer coefficient.

K_{Ti} = radial tire rate in quasi-linear range for a single tire, lb/in.

K_{TQ} = gain in drive torque equation for controlling vehicle velocity, in-lbs/in/sec.

m_{1i}, m_{2i} = rise and decay slopes of the circumferential friction coefficient versus wheel slip function.

ΣM = total vehicle mass, lb-sec^2/in.

M_{CR} = mass of steering system connecting rod, lb-sec^2/in.

M_{Li} = unbalanced front wheel mass, lb-sec^2/in.

M_s = sprung mass, lb-sec^2/in.

M_{SSi} = steering torque applied by steering system connecting rod, in-lb., $i = 1,2$

M_{Ti} = wheel aligning moment, in-lb., $i = 1,2$

M_{uF} = total front unsprung mass, lb-sec^2/in.

M_{XFi}, M_{XRi} = overturning moments acting on the front and rear unsprung masses, respectively, lb-in.

M_{ZFi}, M_{ZRi} = front and rear tire aligning torques, respectively, lb-in.

$M_1 = M_2 = \frac{M_{uF}}{2}$ = front unsprung mass at a single wheel, lb-sec^2/in.

$M_3 = M_{uR}$ = total rear unsprung mass, lb-sec^2/in. (solid axle)

$M_3 = M_4 = \frac{M_{uR}}{2}$ = rear unsprung mass at a single wheel, lb-sec^2/in. (split axle)

N_G = gear ratio of steering gear box.

$\Sigma N_{\phi R}$ = summation of roll moments acting on solid rear axle, lb-in.

$\Sigma N_{\phi u}$ = summation of roll moments acting on the unsprung mass, lb-in.

$\Sigma N_{\theta u}$ = summation of pitch moments acting on the unsprung mass, lb-in.

$\Sigma N_{\psi u}$ = summation of yaw moments acting on the unsprung mass, lb-in.

OF_0, OF_1, OF_2, OF_3 = front tire overturning moment coefficients.

OR_0, OR_1, OR_2, OR_3 = rear tire overturning moment coefficients.

p, q, r = scalar components of angular velocity of the sprung mass, taken along X_B, Y_B, Z_B axes, respectively, rad/sec.

P_{BF1}, P_{BF2}, P_{BR1}, P_{BR2} = coefficients for peak braking coefficient of friction function, front and rear, respectively.

P_{F0}, P_{F1}, P_{F2} = anti-pitch coefficients for front suspension.

P_{FL} = brake line pressure, lb/in^2.

P_{R0}, P_{R1}, P_{R2} = anti-pitch coefficients for rear suspension.

$\overline{PT}$ = caster trail of front wheels, in.

RA_0, RA_1, RA_2 = coefficients in a quadratic cornering stiffness function for a pneumatic tire, rear.

RA_3, RA_4 = coefficients in a quadratic camber stiffness function for a pneumatic tire, rear.

RB_1, RB_2, RB_3, RB_4 = constant coefficients for curves fitted to the lateral friction coefficient properties, rear tires.

R_F, R_R = auxiliary roll stiffness (suspension stiffness in roll), at the front and rear suspensions, respectively, in-lb/rad.

R_{F0}, R_{F1}, R_{F2} = anti-roll coefficients for front suspension.

$(RPS)_i$ = rotational velocity of wheel i, rad/sec.

R_{R0}, R_{R1}, R_{R2} = anti-roll coefficients for rear suspension.

R_W = undeflected radius of wheels, in.

R_{WR} = width of wheel rim, in.

S_i = total suspension force produced by the combination of springs, travel stops, viscous damping, friction, and auxiliary roll stiffness, effective at the wheel for the front suspension, at the spring location for the solid rear axle suspension and at the wheel for the independent rear axle suspension, at wheel i, lb.

SI_i = wheel slip ratio at which peak braking coefficient of friction occurs.

SN_i = skid number ratio of simulated vehicle operating surface to tire data measurement surface.

$(SLIP)_i$ = longitudinal braking slip at wheel i.

T_F, T_R = wheel tread width at front and rear, respectively, in.

T_p = Pitman arm torque applied to connecting rod, in-lb.

T_S = distance between spring mountings on solid rear axle, in.

$\overline{TQ}_{Bi}$ = brake torque at wheel i, in-lb.

$\overline{TQ}_{Di}$ = drive torque at wheel i, in-lb.

$(\overline{TQ}_D)_{max}$ = maximum drive torque, in-lb.

u, v, w = scalar components of linear velocity of the sprung mass, taken along the X_B, Y_B, Z_B axes, respectively, in/sec.

u_{Gi} = longitudinal velocity of the tire-road contact point of wheel i, in/sec.

v_{Gi} = lateral velocity of the tire-road contact point of wheel i, in/sec.

u_i, v_i, w_i = linear velocity components of the wheel centers along the vehicle axes, in/sec.

v_c = desired vehicle velocity, in/sec.

x, y, z = coordinates of vehicle center of gravity in the inertial coordinate axes system, in.

X_B, Y_B, Z_B = coordinates of vehicle center of gravity in the vehicle fixed coordinate system, in.

Y_{CR} = linear displacement of steer connecting rod, in.

Y_{SAi} = distance along the wheel spin axis from the kingpin axis to the wheel center line, in.

z_F = static distance along the Z_L axis between the center of gravity of the sprung mass and the spin axis of the front wheels, in.

Z_{MXi} = wheel contact/lift-off indicator.

z_R = static distance along the Z_P axis between the center of gravity of the sprung mass and the roll center of the rear suspension, in.

β = vehicle body angle of sideslip, rad.

β_i = sideslip angle at wheel i, rad.

$\overline{\beta}_i$ = non-dimensional slip angle variable for wheel i.

β_i' = camber thrust angle at wheel i, rad.

δ_{F1N}, δ_{R1N} = static displacement change in front and rear suspensions due to vehicle load configuration, in.

δ_{FWi} = front wheel steer angle produced by steering system, rad.

δ_{si} = total front suspension deflection from the unloaded vehicle configuration, i = 1,2, in.

δ_{SW} = steering wheel angle, rad.

δ_1, δ_2, δ_3 = suspension deflection relative to the vehicle from the positions of static equilibrium, at the right front wheel center, left front wheel center, and rear axle roll center, respectively, in. (solid axle)

δ_3, δ_4 = suspension deflection relative to the vehicle from positions of static equilibrium, at the right rear wheel center and left rear wheel center, respectively, in. (split axle).

$\Delta\theta_i$ = static front wheel caster bias, i = 1,2

$\Delta\phi_i$ = static front wheel camber bias, i = 1,2

ε_{Ki} = static front wheel toe bias, i = 1,2

ε_{Pi} = free play in steer of front wheels, rad.

ε_{SP} = free play in steering gear box, rad.

ζ_{Si} = total rear suspension deflection from the unloaded vehicle configuration, i = 3,4, in.

ζ_3, ζ_4 = suspension deflections relative to the vehicle, from the positions of static equilibrium, measured at the right and left rear spring positions, respectively, in.

θ_{Li} = front wheel angular displacement, rad.

θ_{Si} = caster angle as a function of relative vertical deflection between wheel and body, rad.

λ_{Bi} = brake torque multipler for wheel i.

λ_{FC}, λ_{FT}, λ_{RC}, λ_{RT} = terms by which K_{Fi} and K_{Ri} are multiplied to represent the suspension spring rate when the suspension deflection stops are encountered.

μ_{PF}, μ_{PR} = peak braking coefficient of friction, front and rear, respectively.

μ_{SF}, μ_{SR} = sliding coefficient of friction, front and rear, respectively.

μ_{yi} = lateral friction coefficient.

μ_i' = circumferential friction coefficient.

μ_{0i}, μ_{1i} = values of circumferential friction coefficient at braking slip equal to zero and one, respectively.

ϕ, θ, Ψ = Euler angles - roll, pitch, and yaw angles - defining the attitude of the sprung mass relative to the space-fixed axis system, rad.

ϕ_{CGi} = camber angle of wheel i relative to its tire-terrain contact plane, rad.

ϕ_i = right front, left front, right rear and left rear wheel camber angles, respectively, relative to the vehicle-fixed coordinate axes, positive when clockwise as viewed from the rear, as a function of relative vertical deflection between wheel and body, rad.

ϕ_R = angular displacement of the rear axle relative to the vehicle about a line parallel to the X_P axis through the rear axle roll center (positive when clockwise as viewed from the rear), rad.

ϕ_{SAi} = kingpin inclination angle, right and left front, respectively, rad. i = 1,2

Ψ_i = heading angle of right front, left front, right rear and left rear wheels relative to vehicle coordinate axes system, positive for clockwise steer as viewed from above vehicle, rad.

Ω_{FC}, Ω_{RC} = suspension deflections for initial wheel contact with front and rear compression bump stops from the positions of static equilibrium relative to the vehicle for quasi-linear load-deflection characteristics of the springs, in.

Ω_{FT}, Ω_{RT} = suspension deflections for initial wheel contact with front and rear rebound bump stops from the positions of static equilibrium relative to the vehicle for quasi-linear load-deflection characteristics of the springs, in.

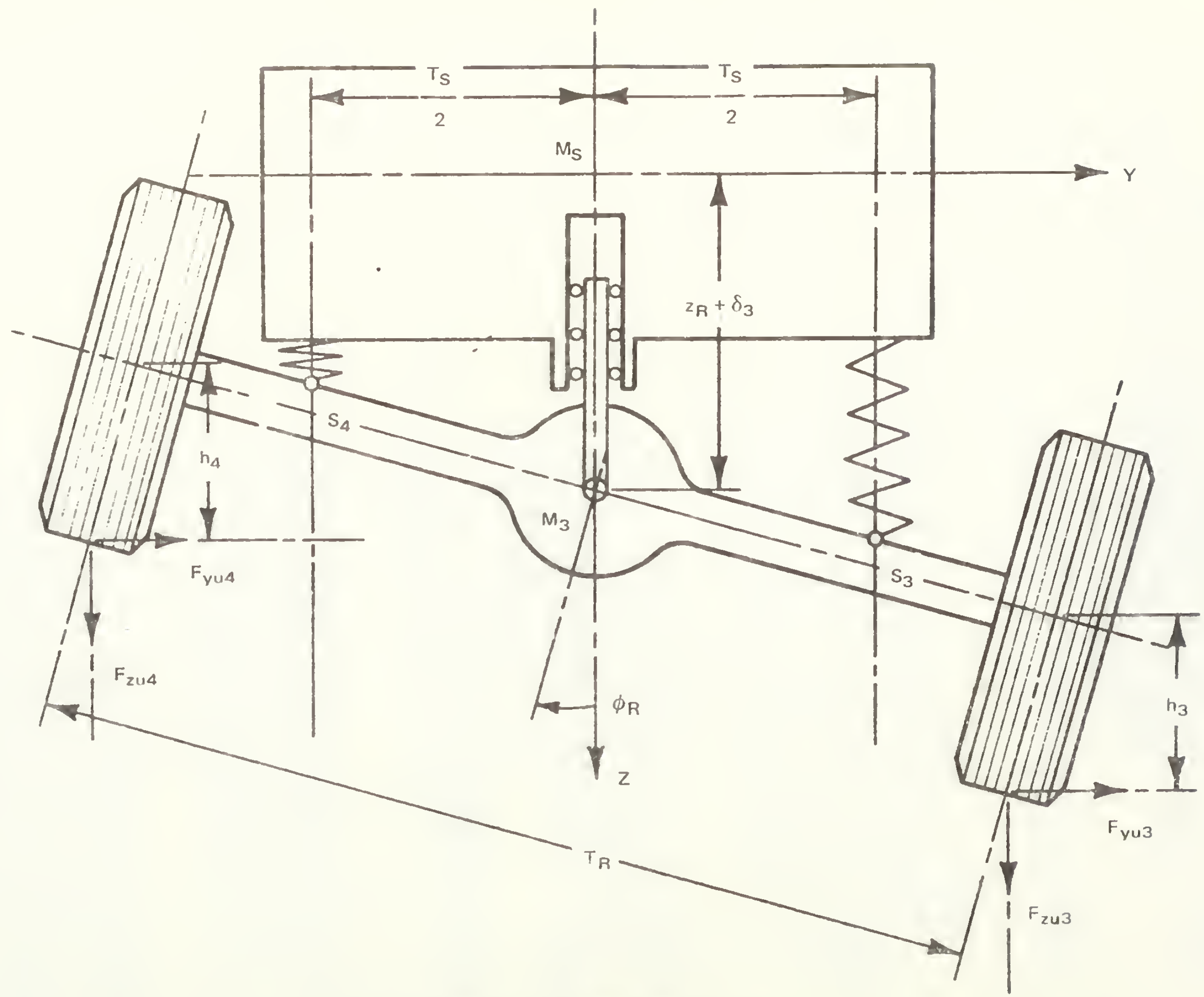

Fig. A-2 REAR AXLE REPRESENTATION

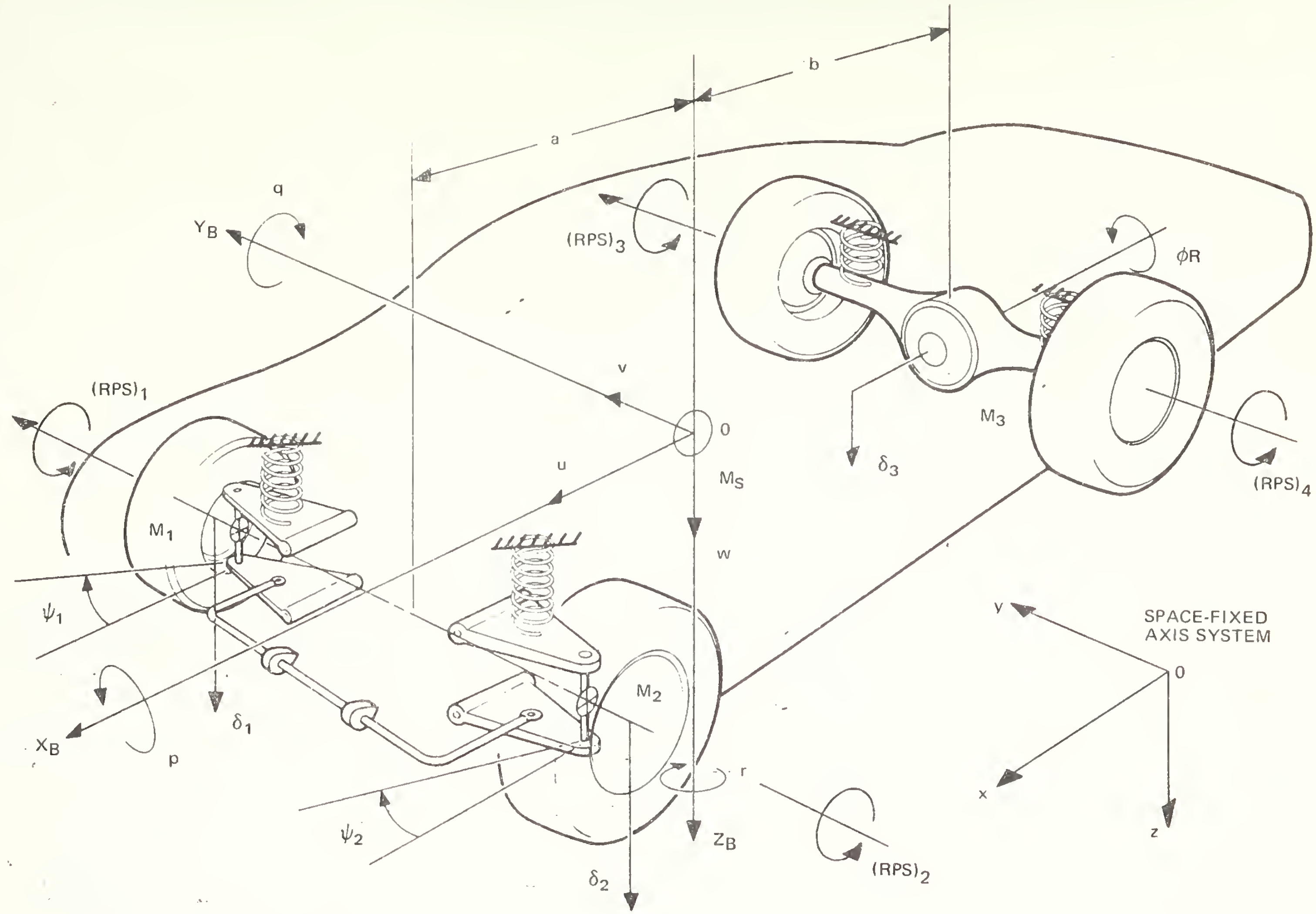

Fig. A-3 ANALYTICAL REPRESENTATION OF THE FOUR-WHEELED VEHICLE

APPENDIX B

FOUR-WHEELED VEHICLE HYBRID SIMULATION IMPLEMENTATION DOCUMENTATION

1. PRESENTED HERE IS THE COMPUTER LISTING OF THE DSL/91 DIGITAL STATIC CHECK PROGRAM

```
*          ********** LISTING OF DSL/91 DIGITAL PROGRAM **********
TITLE ### PROB:52 VEHICLE SIMULATION ###
INCON  SHAPE1=-.0065,SHAPE2=-.0037,SHAPE3=.0050 ,SHAPE4=.0029
INCON  DEL1DT=10.    ,DEL1  =.3830 ,DEL2DT=15.    ,DEL2   = 1.866
INCON  THETA1=60.    ,THETA2=37.5  ,ERR1  =1.     ,ERR2   =-0.6
INCON  DFW2DT=37.    ,DFW2  =0.15  ,YCRDT =80.    ,YCR    =2.55
INCON  RPS1  =43.06 ,RPS2  =43.06 ,RPS3  =43.057,XPS3DT=10000.
INCON  RPS4  =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1   =0.35
INCON  PSI1  =.2140 ,PSI2  =.2040 ,PSI3  =.01667,PSI4   =-.0150
INCON  ZO    =-23.4 ,THEO  =.00209,PHIO  =.00300,RDTO   =-500.0
INCON  U01   =.120  ,U02   =1.01  ,U03   =.900  ,U04    =2.000
INCON  U11   =-.6133,U12   =1.11  ,U13   =1.621 ,U14    =1.700
INCON  AM11  =5.25  ,AM12  =-7.40 ,AM13  =-7.50 ,AM14   =-8.30
INCON  TQFBR =8000. ,TQRBR =7100. ,MT1   =-164.3,MT2    =164.3
INCON  PDTO  =-.12  ,QDTO  =.0900 ,UO    =704.  ,VO     =.1300
INCON  WO    =.0050 ,PO    =.0200 ,QO    =-.0370,RO     =.0110
INCON  F1    =.9    ,F2    =.8    ,F3    =-.3   ,F4     =.6
INCON  GB1   =.2    ,GB2   =.4    ,GB3   =.5    ,GB4    =.85
PARAM  AMS   =5.162 ,AMUF  =0.359 ,AMUR  =0.574 ,TS     = 35.86
PARAM  AIR   =800.  ,RF    =81E03 ,TF    =54.3  ,ER     =50E03
PARAM  RW    =12.85 ,AIFW  =5.815 ,AH1   =200.  ,AH2    =200.
PARAM  AKT1  =812.  ,AKT2  =812.  ,AKT3  =1192. ,AKT4   =1192.
PARAM  AMCR  =0.08  ,CFCR  =200.  ,CCR   =11.   ,AP     =6.06
PARAM  AA1   =5.53  ,AA2   =5.53  ,ANG   =17.5  ,AKSC   =610.
PARAM  ESP   =-6.   ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1    =-.2000
PARAM  EP2   =-.1   ,AIWF  =7.3777,AID   =0.3   ,ARBR   =4.125
PARAM  AIWR  =7.3777,AKF   =133.  ,AKR   =185.  ,ALAMP  =5.1
PARAM  OPT   =2.2   ,CFP   =25.   ,CRP   =45.   ,TR     =53.3
PARAM  AKF1  =52.2  ,AKF2  =52.2  ,AKF3  =100.  ,AKF4   =100.
PARAM  AKR3  =100. ,AKR4  =100.
PARAM  A     =56.3  ,B     =39.0  ,G     =386.4 ,ZF     =10.8
PARAM  ZR    =10.6  ,AMU1  =.1795 ,AMU2  =.1795 ,AMU3   =.2870
PARAM  AMU4  =.2870 ,AMUF  =.3590 ,AMUR  =.5740 ,HFC    =7.20
PARAM  HRC   =4.70  ,CRRC  =0.0110,TANP  =0.0   ,DELSWO=1.425
PARAM  LB1   =1.65  ,LB2   =1.65  ,LB3   =1.0   ,LB4    =1.0
*
* SOLID AXLE IF AXLE = 1
*
PARAM  AXLE  =1
*
* 231'R SCALED FOR BETA TIMES REAL TIME
*
PARAM  BETA  =0.25
*
CONTRL TSTART=0.0,FINTIM=.001,DELT=.001
DYNAMIC
*
* THE FOLLOWING PARAMETERS ARE USED IF THE AXLE IS SPLIT
*
      IF(AXLE.EQ.1) GOTO 1
      PHIR   = 0.
      PHIRD  = 0.
      DEL3   = 0.
      DEL3DT = 0.
      SEL3   = 0.25
      SEL3DT = 69.0
      SEL4   = 0.90
      SEL4DT = 70.0
      GOTO 2
```

```
*
* THE FOLLOWING PARAMETERS ARE USED IF AXLE IS SOLID
*
1     SEL3   = 0.
      SEL3DT = 0.
      SEL4   = 0.
      SEL4DT = 0.
      PHIR   = 0.01695
      PHIRD  = 0.55
      DEL3   = 0.8
      DEL3DT = 20.
*
*SYSTEM EQUATIONS
*
*SUSPENSION FORCE EQUATIONS
*
2     FSA1   =33.1
      FSA2   =48.0
      FSA3   = 186.1
      IF(AXLE.EQ.1) FSA3=95.9
      FSA4   = 188.0
      IF(AXLE.EQ.1) FSA4=50.0
      F2F1   =20.0
      F2F2   =97.41
      F1F1   =CFP
      F1F2   =CFP
      F2R3   = 25.0
      IF(AXLE.EQ.1) F2R3 = 114.0
      F2R4   = 90.0
      IF(AXLE.EQ.1) F2R4=46.02
      F1R3   =CRP
      F1R4   =CRP
*
*ERR1,ERR2 DENOTE LIMITER SETTINGS
*
      AUXRL1 =((DEL2-DEL1)-ERR1)*(RF/(TF*TF))
      AUXRL2 =(-(DEL2-DEL1)-ERR2)*(RF/(TF*TF))
      S1P    = AUXRL1 - FSA1 - F2F1 - F1F1
      S2P    = AUXRL2   - FSA2 - F2F2 - F1F2
      IF(AXLE.EQ.1) S3P=-FSA3-F2R3-F1R3-(RR/TS)*PHIR
      IF(AXLE.NE.1) S3P=-FSA3-F2R3-F1R3+(SEL4-SEL3)*RR/TR**2
      IF(AXLE.EQ.1) S4P=-FSA4-F2R4-F1R4+(RR/TS)*PHIR
      IF(AXLE.NE.1) S4P=-FSA4-F2R4-F1R4-(SEL4-SEL3)*RR/TR**2
      SMP    = S1P + S2P + S3P + S4P
      S1     = S1P+B*AMS*G/(2.*(A+B))
      S2     = S2P+B*AMS*G/(2.*(A+B))
      S3     = S3P+A*AMS*G/(2.*(A+B))
      S4     = S4P+A*AMS*G/(2.*(A+B))
      ZET3   = (TS/2.)*PHIR + DEL3
      IF(AXLE.NE.1) ZET3=SEL3
      ZET3DT = (TS/2.)*PHIRD + DEL3DT
      IF(AXLE.NE.1) ZET3DT=SEL3DT
      ZET4   = -(TS/2.)*PHIR + DEL3
      IF(AXLE.NE.1) ZET4=SEL4
      ZET4DT = -(TS/2.)*PHIRD + DEL3DT
      IF(AXLE.NE.1) ZET4DT=SEL4DT
*
*RADIAL TIRE FORCE AND ROLLING RADIUS EQUATIONS
*
      Z1     = DEL1+ZF+ZO-A*THEO+TF*0.5*PHIO
```

```
      Z2      = DEL2+ZF+ZO-A*THEO-TF*0.5*PHIO
      Z3      = ZO+B*THEO+TR*0.5*PHIO+ZR+SEL3
      IF(AXLE.EQ.1) Z3=ZO+B*THEO+TR*0.5*PHIO+ZR+TR*0.5*PHIR+DEL3
      Z4      = ZO+B*THEO-TR*0.5*PHIO+ZR+SEL4
      IF(AXLE.EQ.1) Z4=ZO+B*THEO-TR*0.5*PHIO+ZR-TR*0.5*PHIR+DEL3
      H1      = -Z1
      H2      = -Z2
      H3      = -Z3
      H4      = -Z4
      RHO1    = RW-H1
      RHO2    = RW-H2
      RHO3    = RW-H3
      RHO4    = RW-H4
      FR1     = 0.
      IF((RW+Z1).GT.0.) FR1=AKT1*(RW+Z1)
      FR2     = 0.
      IF((RW+Z2).GT.0.) FR2=AKT2*(RW+Z2)
      FR3     = 0.
      IF((RW+Z3).GT.0.) FR3=AKT3*(RW+Z3)
      FR4     = 0.
      IF((RW+Z4).GT.0.) FR4=AKT4*(RW+Z4)
      FXU1    = FR1*(THEO-U1P*COS(PSI1)-F1*AMU1*SIN(PSI1)*GB1)
      FXU2    = FR2*(THEO-U2P*COS(PSI2)-F2*AMU2*SIN(PSI2)*GB2)
      FXU3    = FR3*(THEO-U3P*COS(PSI3)-F3*AMU3*SIN(PSI3)*GB3)
      FXU4    = FR4*(THEO-U4P*COS(PSI4)-F4*AMU4*SIN(PSI4)*GB4)
      FYU1    = FR1*(-PHIO-U1P*SIN(PSI1)+F1*AMU1*COS(PSI1)*GB1)
      FYU2    = FR2*(-PHIO-U2P*SIN(PSI2)+F2*AMU2*COS(PSI2)*GB2)
      FYU3    = FR3*(-PHIO-U3P*SIN(PSI3)+F3*AMU3*COS(PSI3)*GB3)
      FYU4    = FR4*(-PHIO-U4P*SIN(PSI4)+F4*AMU4*COS(PSI4)*GB4)
      NPHIR   = -FR3*(TR*0.5+Z3*PHIR)+FR4*(TR*0.5-Z4*PHIR)-FYU3*...
                 (TR*0.5*PHIR-Z3)-FYU4*(-TR*0.5*PHIR-Z4)+(S3-S4)*TS*0.5
*
*FRONT WHEEL EQUATIONS OF MOTION
*
      DEL1DD = SMP/AMS-TF*0.5*PDTO+A*QDTO+2./AMUF*(-FR1+S1-FYU1*...
                TAN(2.*HFC/TF))+G
      DEL2DD = SMP/AMS+TF*0.5*PDTO+A*QDTO+2./AMUF*(-FR2+S2-FYU2*...
               TAN(2.*HFC/TF))+G
*
*REAR WHEELS AND AXLE COMBINATION
*
*SOLID
*
      DEL3DD = SMP/AMS+G+(S3+S4-FR3-FR4+(FXU3+FXU4)*TANP)/AMUR-B*QDTO
      PHIRDD = -PDTO+(NPHIR-(FYU3+FYU4)*(CRRC*DEL3+HRC)-TS*0.5*...
                (FYU3-FXU4)*TANP)/AIR
*
*SPLIT
*
      SEL3DD = SMP/AMS-TR*0.5*PDTO-B*QDTO+2./AMUR*(-FR3+S3-FYU3*...
                TAN(2.*HRC/TR))+G
      SEL4DD = SMP/AMS+TR*0.5*PDTO-B*QDTO+2./AMUR*(-FR4+S4+FYU4*...
                TAN(2.*HRC/TR))+G
*
*STEERING SYSTEM EQUATIONS
*ESP,EP1,EP2 DENOTE LIMITER SETTINGS
      TP      = ANG*AKSC*(DELSWO-ANG*YCR/AP-ESP/2.)
      AMSS1   = AKSL1*((DFW1-YCR/AA1)-EP1/2.)
      AMSS2   = AKSL2*((DFW2-YCR/AA2)-EP2/2.)
*
```

```
      DFW1DD =  (-AH1*DFW1DT+MT1-AMSS1)/AIFW-RDTO
      DFW2DD =  (-AH2*DFW2DT+MT2-AMSS2)/AIFW-RDTO
      YCRDD  =  (1./AMCR)*(-CFCR - CCR*YCRDT + TP/AP + AMSS1/AA1 +  ...
                AMSS2/AA2)
*
*WHEEL ROTATIONAL EQUATIONS
*
*
* CIRCUMFERENTIAL FRICTION COEFFICIENT
*
      U1       =  UO-TF*0.5*RO+ZF*QO
      U2       =  UO+TF*0.5*RO+ZF*QO
      U3       =  UO-TR*0.5*RO+ZR*QO
      U4       =  UO+TR*0.5*RO+ZR*QO
      V1       =  VO+A*RO-ZF*PO+Z1*PO
      V2       =  VO+A*RO-ZF*PO+Z2*PO
      V3       =  VO-B*RO-ZR*PO+Z3*PO
      IF(AXLE.EQ.1)  V3=V3+Z3*PHIRD
      V4       =  VO-B*RO-ZR*PO+Z4*PO
      IF(AXLE.EQ.1)  V4=V4+Z4*PHIRD
      W1       =  WO-A*QO+TF*0.5*PO-DEL1DT
      W2       =  WO-A*QO-TF*0.5*PO+DEL2DT
      W3       =  WO-B*QO+DEL3DT+TR*0.5*PO
      IF(AXLE.EQ.1)  W3=WO-B*QO+DEL3DT+(PHIRD+PO)*TR*0.5
      W4       =  WO+B*QO+DEL4DT-TR*0.5*PO
      IF(AXLE.EQ.1)  W4=WO+B*QO+DEL3DT-(PHIRD+PO)*TR*0.5
      UG1      =  U1+THEO*W1
      UG2      =  U2+THEO*W2
      UG3      =  U3+THEO*W3
      UG4      =  U4+THEO*W4
      VG1      =  V1-PHIO*W1
      VG2      =  V2-PHIO*W2
      VG3      =  V3-PHIO*W3
      VG4      =  V4-PHIO*W4
      XI1      =  1.+RPS1*Z1/(UG1*COS(PSI1)+VG1*SIN(PSI1))
      XI2      =  1.+RPS2*Z2/(UG2*COS(PSI2)+VG2*SIN(PSI2))
      XI3      =  1.+RPS3*Z3/(UG3+VG3*PSI3)
      XI4      =  1.+RPS4*Z4/(UG4+VG4*PSI4)
*
*WHEEL SLIP

      SLIP1  =  XI1
      IF(ABS(XI1).GT.1.)  SLIP1=SIGN(1.,XI1)
      SLIP2  =  XI2
      IF(ABS(XI2).GT.1.)  SLIP2=SIGN(1.,XI2)
      SLIP3  =  XI3
      IF(ABS(XI3).GT.1.)  SLIP3=SIGN(1.,XI3)
      SLIP4  =  XI4
      IF(ABS(XI4).GT.1.)  SLIP4=SIGN(1.,XI4)
* ### TIRE CIRCUMFERENTIAL FORCE ###
      AM21     =  U11-U01
      AM22     =  U12-U02
      AM23     =  U13-U03
      AM24     =  U14-U04
      SI1      =  U01/(AM11-AM21)
      SI2      =  U02/(AM12-AM22)
      SI3      =  U03/(AM13-AM23)
      SI4      =  U04/(AM14-AM24)
      U1P      =  AM11*SLIP1
      IF(SLIP1.GT.SI1)  U1P=AM21*SLIP1+U01
```

```
      U2P    = AM12*SLIP2
      IF(SLIP2.GT.SI2) U2P=AM22*SLIP2+U02
      U3P    = AM13*SLIP3
      IF(SLIP3.GT.SI3) U3P=AM23*SLIP3+U03
      U4P    = AM14*SLIP4
      IF(SLIP4.GT.SI4) U4P=AM24*SLIP4+U04
      FC1    = -U1P*FR1
      FC2    = -U2P*FR2
      FC3    = -U3P*FR3
      FC4    = -U4P*FR4
      RPS1DT = -(FC1*H1-TQFBR*LB1)/AIWF
      RPS2DT = -(FC2*H2-TQFBR*LB2)/AIWF
      DENOM = AIWR + AID*ARBR*ARBR/4.
      TERM   = AID*ARBR*ARBR/4.
      RPS4DT = -(FC4*H4-TQRBR*LB4+TERM*XPS3DT)/DENOM
      RPS3DT = -(FC3*H3-TQRBR*LB3+TERM*XPS4DT)/DENOM
*
*SPARE TIRES
*
      TIN    =1E-04
      THER1  =THETA1/57.3
      THER2  =THETA2/57.3
      THE1DT =57.3*RPS1
      THE2DT =57.3*RPS2
TERMINAL
*
* 231-R POTS
*
      Q200     =AKF1*10.0*TIN
      Q201     =.5512
      Q202    = 1.0/(20.0*AMCP)*BETA
      Q203     =.6755
      Q204    = 2.0/3.0*BETA
      Q205     =YCRDT/200.
      Q206     =YCP/3.
      Q207 = .2000
      Q208     =DFW2DT/100.
      Q209     =2.*DFW2
      Q210      =AKR3*10.0*TIN
      Q211    =.9999
      Q212    = AH2/(100.0*AIFW)*BETA
      Q213      =.9313
      Q214    = AKSL2/(40000.0*AIFW)*BETA
      Q215      =AKR4*10.0*TIN
      Q216    =.9999
      Q218      =.9218
      Q219    =(AKSC*ANG/(AP*2000.0))/20.
      Q220      =AKF2*10.0*TIN
      Q221      =.5512
      Q222    = AH1/(100.0*AIFW)*BETA
      Q223     =.6754
      Q224    = AKSL1/(40000.0*AIFW)*BETA
      Q235     =DFW1DT/100.
      Q236     =2.*DFW1
      Q255    =.8100
      Q256    =.7152
      Q257    = CFCR/20000.0
      Q258    = CCR/100.0
      Q265    =.7652
      Q266    =.7056
```

```
      Q267    = AKSL2/(AA2*40000.0)
      Q268    =3.0/AA2
      Q275    =.8102
      Q276    =.7183
      Q285    =.7652
      Q286    =.7038
      Q287    =3.0/AA1
      Q288    = AKSL1/(AA1*40000.0)
      P201    =.4724
      P215    =.9999*BETA
      P217    = 3.0*ANG/(10.0*AP)
      P221    =.4724
      P230    =.9999*BETA
*
*231-R AMP'S
*
      A250    =YCRDT/200.
      A251    =-YCR/3.
      A260    =-DFW2DT/100.
      A261    =2.*DFW2
      A280    =-DFW1DT/100.
      A281    =2.*DFW1
      A200    =DEL1/10.
      A201    =-F2F1/1000.
      A210    =ZET3/10.
      A211    =-F2R3/1000.
      A215    =ZET4/10.
      A216    =-F2R4/1000.
      A220    =DEL2/10.
      A221    =-F2F2/1000.
      A227    =-.2*DFW2
      A230    =-FSA1/1000.
      A231    =-FSA2/1000.
      A232    =-FSA3/1000.
      A233    =-FSA4/1000.
      A237    =-.2*DFW1
      A238   =-(-MT1/AIFW+RDTO)*BETA
      A239   =-(-MT2/AIFW+RDTO)*BETA
      A240    =DEL1DT/100.
      A241    =DEL2DT/100.
      A242    =-ZET3DT/100.
      A243    =ZET3DT/100.
      A244    =-ZET4DT/100.
      A245    =ZET4DT/100.
      A252    =-(AMCR*YCRDD/20000.)
      A253    =-CFCR/20000.
      A254   =-CFCR/20000.
      A262    =-2.*(DFW2-(YCR/AA2))
      A263    =2.*AMSS2/AKSL2
      A264    =-A263
      A270    = -(DELSWO-(ANG*YCR)/AP)/10.
      A271    =(ESP/2.)/10.
      A272    =-(A270+A271)
      A273    =-A250
      A282    =-2.*(DFW1-(YCR/AA1))
      A283    =2.*AMSS1/AKSL1
      A284    =-A283
      A292    =2.*(EP1/2.)
      A293    =2.*(EP2/2.)
*
```

```
*231 DERIVATIVES
*
      D250    =YCRDD/20000.*BETA
      D251    =-YCRDT/30.*BETA
      D260    =-DFW2DD/1000.*BETA
      D261    =DFW2DT/5.*BETA
      D280    =-DFW1DD/1000.*BETA
      D281    =DFW1DT/5.*BETA
*
*680 POTS
*REMAINING 680 POTS OBTAINED FROM IPOT SUBROUTINE
*
      P00       =DEL1DT/100.
      P18       =DEL3/10.
      P20       =4.*PHIR
      P23       =PHIRD
      P30       =DEL1/10.
      P37       =DEL2DT/100.
      P38       =DEL2/10.
      P43       =DEL3DT/100.
      P48       =SEL3DT/100.
      P57       =SEL3/10.
      P77       =SEL4DT/100.
      P78       =SEL4/10.
      P90       =THETA1/200.
      P95       =THETA2/200.
      P101      =RPS1/100
      P104      =RPS2/100
      P110      =RPS3/100
      P114      =RPS4/100
*
*UNSCALED DAC VALUES FOR SYSTEM EQUATIONS
*
      DAC00  = -MT1/AIFW+RDTO
      DAC01  = RW+ZF+ZO-A*THEO+TF*0.5*PHIO
      DAC02  = -MT2/AIFW+RDTO
      DAC03  = RW+ZF+ZO-A*THEO-TF*0.5*PHIO
      DAC04  = AM21-AM11
      DAC05  = -TF*0.5*PDTO+A*QDTO+B*AMS*G/((A+B)*AMUF)+G-2.*FYU1*...
               TAN(2.*HFC/TF)/AMUF
      DAC06  = AM22-AM12
      DAC07  = TF*0.5*PDTO+A*QDTO+B*AMS*G/((A+B)*AMUF)+G-2.*FYU2*...
               TAN(2.*HFC/TF)/AMUF
      DAC08  = -TQFRR
      DAC09  = -TQRRR
      DAC10  = DELSWO
      DAC11  = -TR*0.5*PDTO-B*QDTO+A*AMS*G/((A+B)*AMUR)+G-2.*FYU3*...
               TAN(2.*HRC/TR)/AMUR
      DAC12  = (-TR*0.5-Z3*PHIR)*AKT3/AIR
      DAC13  = G-B*QDTO+(A*AMS*G/(A+B)+(FXU3+FXU4)*TANP)/AMUR
      DAC14  = (TR*0.5-Z4*PHIR)*AKT4/AIR
      DAC15  = -PDTO+(-(FYU3+FYU4)*(CRRC*DEL3+HRC)-TS*0.5*(FXU3-FXU4)...
              *TANP-FYU3*(TR*0.5*PHIR-Z3)-FYU4*(-TR*0.5*PHIR-Z4))/AIR
      DAC16  = AM23-AM13
      DAC17  = RW+ZR+ZO+B*THEO+PHIO*TR*0.5
      DAC18  = AM24-AM14
      DAC19  = RW+ZR+ZO+B*THEO-PHIO*TR*0.5
      DAC20  = AM14
      DAC21  = AM13
      DAC22  = AM11
```

```
      DAC23   = AM12
      DAC24   = UG1*COS(PSI1)+VG1*SIN(PSI1)
      DAC25   = UG2*COS(PSI2)+VG2*SIN(PSI2)
      DAC26   = UG3+VG3*PSI3
      DAC27   = U03
      DAC28   = UG4+VG4*PSI4
      DAC29   = U04
      DAC30   = U02
      DAC31   = U01
      DAC32   = -SI1
      DAC33   = -SI2
      DAC34   = -SI3
      DAC35   = -SI4
      DAC36   = TR*0.5*PDTO-B*QDTO+A*AMS*G/((A+B)*AMUR)+G+2.*FYU4*...
                TAN(2.*HRC/TR)/AMUR
*
* SCALE FACTORS FOR D/A CONVERTERS
*
      DA00    = DAC00/10000.*BETA
      DA01    = DAC01/10.
      DA02    = DAC02/10000.*BETA
      DA03    = DAC03/10.
      DA04    = DAC04/20.
      DA05    = DAC05/10000.
      DA06    = DAC06/20.
      DA07    = DAC07/10000.
      DA08    = DAC08/40000.
      DA09    = DAC09/40000.
      DA10    = DAC10/10.
      DA11    = DAC11/10000.
      DA12    = DAC12/100.
      DA13    = DAC13/10000.
      DA14    = DAC14/100.
      DA15    = DAC15/100.
      DA16    = DAC16/20.
      DA17    = DAC17/10.
      DA18    = DAC18/20.
      DA19    = DAC19/10.
      DA20    = DAC20/20.
      DA21    = DAC21/20.
      DA22    = DAC22/20.
      DA23    = DAC23/20.
      DA24    = DAC24/1500.
      DA25    = DAC25/1500.
      DA26    = DAC26/1500.
      DA27    = DAC27/20.
      DA28    = DAC28/1500.
      DA29    = DAC29/20.
      DA30    = DAC30/20.
      DA31    = DAC31/20.
      DA32    = DAC32
      DA33    = DAC33
      DA34    = DAC34
      DA35    = DAC35
      DA36    = DAC36/10000.
*
*  680 AMP'S
      A000    =-DEL1DT/100.
      A002    =DEL1/10.
      A005    =-DEL2DT/100.
```

```
      A007    =DEL2/10.
      A010    =-DEL3DT/100.
      A012    =DEL3/10.
      A015    =-PHIRD
      A017    =4.*PHIR
      A040    =-SEL3DT/100.
      A050    =SEL3/10.
      A080    =-SEL4DT/100.
      A085    =SEL4/10.
      A090    =THETA1/200.
      A095    =THETA2/200.
      A100    =RPS1/100.
      A105    =RPS2/100.
      A110    =-RPS3/100.
      A115    =-RPS4/100.
      T51     =A237
      T52     =A227
      T80     =A230
      T82     =A232
      T83     =A233
      T84     =A201
      T85     =A221
      T86     =A211
      T87     =A216
      T88     =A231
      A003    =-DEL1/10.
      A004    =SIN(THER1)
      A006    =-RPS2/100.
      A008    =(-H1*RPS1/(UG1*COS(PSI1)+VG1*SIN(PSI1)))/2.
      A009    =COS(THER2)
      A011    =AUXRL2/1000.
      A014    =-COS(THER1)
      A016    =-S1P/1000.
      A018    =H1*RPS1/1500.
      A019    =S1P/1000.
      A020    =SLIP4
      A021    =-S2P/1000.
      A022    =RPS4DT/10000.
      A023    =-FC1/(4.*AKT1)
      A024    =S2P/1000.
      A026    =-S3P/1000.
      A028    =-(H1*RR1*U1P)/(60.*AKT1)
      A029    =S3P/1000.
      A030    =U3P/2.
      A032    =SHAPE1
      A033    =SHAPE2
      A034    =SIN(THER1)
      A035    =ZET4DT/100.
      A036    =-ZET3/10.
      A037    =SIN(THER1)
      A038    =SHAPE3
      A039    =SIN(THER2)
      A041    =U4P/2.
      A042    =SIN(THER2)
      A044    =SHAPE4
      A045    =-ZET4/10.
      A046    =ZET3DT/100.
      A048    =RHO3/2.
      A049    =-H3/15.
      A051    =-S4P/1000.
```

```
      A052   =-A050
      A053   =H2*RPS2/1500.
      A054   =S4P/1000.
      A055   =(S3P-S4P)/2000.
      A056   =-RPS1/100.
      A057   =-A039
      A058   =RHO4/2.
      A059   =-H4/15.
      A060   =AUXRL1/1000.
      A061   =ERR2/10.
      A062  =-A014
      A063   =-(H2*FR2*U2P)/(60.*AKT2)
      A064   =-SLIP3
      A065   =-(DEL2-DEL1)/10.
      A066   =SMP/1000.
      A068   =-FC2/(4.*AKT2)
      A069   =-A034
      A070   =ERR1/10.
      A071   =-(SEL4-SEL3)/10.
      A072   =-SIN(THER1)
      A073   =(-H3*RPS3/(UG3+VG3*PSI3))/2.
      A074   =(SEL4-SEL3)*RR/(TP**2*1000.)
      A075   = -(SLIP4*(AM24-AM14)+U04)/20.
      A076   =RPS3DT/10000.
      A077   =COS(THER1)
      A078   =H3*RPS3/1500.
      A079   =-A074
      A081   =SLIP2
      A082   =-SIN(THER2)
      A083   =-(H3*FR3*U3P)/(60.*AKT3)
      A084   =-H2/15.
      A086   =-RHO1/2.
      A087   =COS(THER2)
      A088   =-FC3/(4.*AKT3)
      A089   =-H1/15.
      A091   =U1P/2.
      A092   =SLIP3
      A093   =(-H2*RPS2/(UG2*COS(PSI2)+VG2*SIN(PSI2)))/2.
      A094   = -(SLIP3*(AM23-AM13)+U03)/20.
      A096   =-RHO2/2.
      A097   =-SLIP4
      A099   =SIN(THER2)
      A101   =SLIP1
      A102   =-SLIP1
      A103   =(-H4*RPS4/(UG4+VG4*PSI4))/2.
      A104   = -(SLIP1*(AM21-AM11)+U01)/20.
      A106   =-RHO3/2.
      A108   =H4*RPS4/1500.
      A109   = -(SLIP2*(AM22-AM12)+U02)/20.
      A111   =U2P/2.
      A113   =-(H4*FR4*U4P)/(60.*AKT4)
      A114   =-SLIP2
      A116   =-RHO4/2.
      A117   =-A087
      A118   =-FC4/(4.*AKT4)
*    680 DERIVATIVES
      D000   =DEL1DD/1000.
      D002   =-DEL1DT/100.
      D005   =DEL2DD/1000.
      D007   =-DEL2DT/100.
```

```
      D010   =DEL3DD/1000.
      D012   =-DEL3DT/100.
      D015   =PHIRDD/10.
      D017   =-PHIRD/2.5
      D040   =SEL3DD/1000.
      D050   =-SEL3DT/100.
      D080   =SEL4DD/1000.
      D085   =-SEL4DT/100.
      D090   =THE1DT/2000.
      D095   =THE2DT/2000.
      D100   =-RPS1DT/1000.
      D105   =-RPS2DT/1000.
      D110   =RPS3DT/1000.
      D115   =RPS4DT/1000.
      DUMMY  =  DEBUG(1.,0.)
      CALL PUNCH
END
PARAM AXLE=0
END
STOP
```

```
                *** DSL/91  SIMULATION DATA ***                                                          74.183        12:31:15.15
        TITLE === PROBU52 VEHICLE SIMULATION ===
        INCON  SHAPE1=-.0065,SHAPE2=-.0037,SHAPE3=.0050 ,SHAPE4=.0029
        INCON  DEL1DT=10.    ,DEL1  =.3830 ,DEL2DT=15.    ,DEL2  = 1.866
        INCON  THETA1=60.    ,THETA2=37.5  ,ERR1  =1.     ,ERR2  =-0.6
        INCON  DFW2DT=37.    ,DFW2  =0.15  ,YCRDT =80.    ,YCR   =2.55
        INCON  RPS1  =43.06 ,RPS2  =43.06 ,RPS3  =43.057,XPS3DT=10000.
        INCON  RPS4  =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1  =0.35
        INCON  PSI1  =.2140 ,PSI2  =.2040 ,PSI3  =.01667,PSI4  =-.0150
        INCON  ZO    =-23.4 ,THEO  =.00209,PHIO  =.00300,RDTO  =-500.0
        INCON  U01   =.120  ,U02   =1.01  ,U03   =.900  ,U04   =2.000
        INCON  U11   =-.6133,U12   =1.11  ,U13   =1.621 ,U14   =1.700
        INCON  AM11  =5.25  ,AM12  =-7.40 ,AM13  =-7.50 ,AM14  =-8.30
        INCON  TQFBR =8000. ,TQRBR =7100. ,MT1   =-164.3,MT2   =164.3
        INCON  PDTO  =-.12  ,QDTO  =.0900 ,UO    =704.  ,VO    =.1300
        INCON  WO    =.0050 ,PO    =.0200 ,QO    =-.0370,RO    =.0110
        INCON  F1    =.9    ,F2    =.8    ,F3    =-.3   ,F4    =.6
        INCON  GB1   =.2    ,GB2   =.4    ,GB3   =.5    ,GB4   =.85
        PARAM  AMS   =5.162 ,AMUF  =0.359 ,AMUR  =0.574 ,TS    = 35.86
        PARAM  ATR   =800.  ,RF    =81E03 ,TF    =54.3  ,RR    =50E03
        PARAM  RW    =12.85 ,AIFW  =5.815 ,AH1   =200.  ,AH2   =200.
        PARAM  AKT1  =812.  ,AKT2  =812.  ,AKT3  =1192. ,AKT4  =1192.
        PARAM  AMCR  =0.08  ,CFCR  =200.  ,CCR   =11.   ,AP    =6.06
        PARAM  AA1   =5.53  ,AA2   =5.53  ,ANG   =17.5  ,AKSC  =610.
        PARAM  ESP   =-6.   ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1   =-.2000
        PARAM  EP2   =-.1   ,AIWF  =7.3777,AIO   =0.3   ,ARBR  =4.125
        PARAM  AIWR  =7.3777,AKF   =133.  ,AKR   =185.  ,ALAMF =5.1
        PARAM  ORT   =2.2   ,CFP   =25.   ,CRP   =45.   ,TP    =53.3
        PARAM  AKF1  =52.2  ,AKF2  =52.2  ,AKF3  =100.  ,AKF4  =100.
        PARAM  AKR3  =100.  ,AKR4  =100.
        PARAM  A     =56.3  ,B     =39.0  ,G     =386.4 ,ZF    =10.8
        PARAM  ZR    =10.6  ,AMU1  =.1795 ,AMU2  =.1795 ,AMU3  =.2870
        PARAM  AMU4  =.2870 ,AMUF  =.3590 ,AMUR  =.5740 ,HFC   =7.20
        PARAM  HRC   =4.70  ,CRRC  =0.0110,TANP  =0.0   ,DELSWO=1.425
        PARAM  LB1   =1.65  ,LB2   =1.65  ,LB3   =1.0   ,LB4   =1.0
        PARAM  AXLE  =1
        PARAM  BETA  =0.25
        CONTRL TSTART=0.0,FINTIM=.001,DELT=.001
        END

***DSL MESSAGE 20***   NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.0  SECONDS.                                                                 74.183        12:31:16.04

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.1000E-02
```

TIME	1.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0
FINTIM	1.0000E-03								
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DFLADC	7.2370E 75
DELDAC	7.2370E 75								
DELSTP	7.2370E 75	DELMRK	7.2370E 75	SHAPE1	-6.5000E-03	SHAPE2	-3.7000E-03	SHAPE3	5.0000E-03
SHAPE4	2.9000E-03								
DEL1DT	1.0000E 01	DEL1	3.8300E-01	DEL2DT	1.5000E 01	DEL2	1.8660E 00	THETA1	6.0000E 01
THETA2	3.7500E 01								
ERR1	1.0000E 00	ERR2	-6.0000E-01	DFW2DT	3.7000E 01	DFW2	1.5000E-01	YCRDT	8.0000E 01
YCR	2.5500E 00								
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS3DT	1.0000E 04	RPS4	4.3057E 01
XPS4DT	1.0000E 04								
DFW1DT	3.0000E 01	DFW1	3.5000E-01	PSI1	2.1400E-01	PSI2	2.0400E-01	PSI3	1.6670E-02
PSI4	-1.5000E-02								
ZO	-2.3400E 01	THEO	2.0900E-03	PHIO	3.0000E-03	RDTO	-5.0000E 02	U01	1.2000E-01
U02	1.0100E 00								
U03	9.0000E-01	U04	2.0000E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00
U14	1.7000E 00								
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-8.3000E 00	TQFBR	8.0000E 03
TQRBR	7.1000E 03								
MT1	-1.6430E 02	MT2	1.6430E 02	PDTO	-1.2000E-01	QDTO	9.0000E-02	UO	7.0400E 02
VO	1.3000E-01								
WO	5.0000E-03	PO	2.0000E-02	QO	-3.7000E-02	RO	1.1000E-02	F1	9.0000E-01
F2	8.0000E-01								
F3	-3.0000E-01	F4	6.0000E-01	GB1	2.0000E-01	GB2	4.0000E-01	GB3	5.0000E-01
GB4	8.5000E-01								
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	ATR	8.0000E 02
RF	8.1000E 04								
TF	5.4300E 01	RR	5.0000E 04	RW	1.2850E 01	AIFW	5.8150E 00	AH1	2.0000E 02
AH2	2.0000E 02								
AKT1	8.1200E 02	AKT2	8.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	8.0000E-02
CFCR	2.0000E 02								

CCR	1.1000E 01	AR	6.0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02
ESP	-6.0000E 00	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-01	EP2	-1.0000E-01	AIWF	7.3777E 00
AID	3.0000E-01	ARHR	4.1250E 00	AIWR	7.3777E 00	AKF	1.3300E 02	AKR	1.8500E 02	ALAMF	5.1000E 00
ORT	2.2000E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01	AKF1	5.2200E 01	AKF2	5.2200E 01
AKF3	1.0000E 02	AKF4	1.0000E 02	AKR3	1.0000E 02	AKR4	1.0000E 02	A	5.6300E 01	B	3.9000E 01
G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
AMU4	2.8700E-01	HFC	7.2000E 00	HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWO	1.4250E 00
LB1	1.6500E 00	LB2	1.6500E 00	LB3	1.0000E 00	LB4	1.0000E 00	AXLE	1.0000E 00	BETA	2.5000E-01
S3P	-2.8132E 02	S4P	-1.1460E 02	ZZ0001	0.0	ZZ0002	0.0	PHIR	1.8950E-02	PHIRD	5.5000E-01
DEL3	8.0000E-01	DEL3DT	2.0000E 01	SEL3	0.0	SEL3DT	0.0	SEL4	0.0	SEL4DT	0.0
FSA1	3.3100E 01	FSA2	4.8000E 01	FSA3	9.5900E 01	FSA4	5.0000E 01	F2F1	2.0000E 01	F2F2	9.7410E 01
F1F1	2.5000E 01	F1F2	2.5000E 01	F2R3	1.1400E 02	F2R4	4.6020E 01	F1R3	4.5000E 01	F1R4	4.5000E 01
AUXRL1	1.3269E 01	AUXRL2	-2.4257E 01	S1P	-6.4831E 01	S2P	-1.9467E 02	SMP	-6.5542E 02	S1	3.4330E 02
S2	2.1346E 02	S3	3.0785E 02	S4	4.7457E 02	ZET3	1.1398E 00	ZET3DT	2.9861E 01	ZET4	4.6023E-01
ZET4DT	1.0139E 01	Z1	-1.2253E 01	Z2	-1.0933E 01	Z3	-1.1334E 01	Z4	-1.2503E 01	H1	1.2253E 01
H2	1.0933E 01	H3	1.1334E 01	H4	1.2503E 01	RHO1	5.9679E-01	RHO2	1.9169E 00	RHO3	1.5165E 00
RHO4	3.4656E-01	FR1	4.8459E 02	FR2	1.5565E 03	FR3	1.8077E 03	FR4	4.1310E 02	FXU1	2.1540E 01
FXU2	-1.6027E 03	FXU3	-2.0205E 03	FXU4	-7.9518E 02	FYU1	1.9030E 01	FYU2	-2.4560E 02	FYU3	-1.1700E 02
FYU4	7.1174E 01	NPHIR	-3.9137E 04	DEL1DD	-5.4820E 02	DEL2DD	-6.8493E 03	DEL3DD	-2.2499E 03	PHIRDD	-4.8532E 01
SEL3DD	-4.8940E 03	SEL4DD	5.1111E 02	TP	-3.1372E 04	AMSS1	-1.3012E 03	AMSS2	-3.0551E 04	DFW1DD	-3.3630E 02
DFW2DD	4.5095E 03	YCRDD	-1.5021E 05	U1	7.0330E 02	U2	7.0390E 02	U3	7.0331E 02	U4	7.0390E 02
V1	2.8824E-01	V2	3.1464E-01	V3	-6.9711E 00	V4	-7.6380E 00	W1	-7.3689E 00	W2	1.6545E 01
W3	3.6638E 01	W4	3.3715E 00	UG1	7.0329E 02	UG2	7.0393E 02	UG3	7.0339E 02	UG4	7.0391E 02
VG1	3.1034E-01	VG2	2.6500E-01	VG3	-7.0810E 00	VG4	-7.6481E 00	XI1	2.3234E-01	XI2	3.1711E-01
XI3	3.0612E-01	XI4	2.3531E-01	SLIP1	2.3234E-01	SLIP2	3.1711E-01	SLIP3	3.0612E-01	SLIP4	2.3531E-01
AM21	-7.3330E-01	AM22	1.0000E-01	AM23	7.2100E-01	AM24	-3.0000E-01	SI1	2.0056E-02	SI2	-1.3467E-01
SI3	-1.0948E-01	SI4	-2.5000E-01	U1P	-5.0371E-02	U2P	1.0417E 00	U3P	1.1207E 00	U4P	1.9294E 00
FC1	2.4410E 01	FC2	-1.[illegible]14E 03	FC3	-2.0259E 03	FC4	-7.9704E 02	RPS1DT	1.7486E 03	RPS2DT	4.1920E 03
DENOM	8.6539E 00	TERM	1.2762E 00	RPS4DT	4.9735E 02	RPS3DT	1.9989E 03	TIN	1.0000E-04	THER1	1.0471E 00
THER2	6.5445E-01	THR1DT	2.4673E 03	THR2DT	2.4673E 03	ZZ0003	0.0	ZZ0004	0.0	Q200	5.2200E-02
Q201	5.5120E-01	Q202	1.5625E-01	Q203	6.7550E-01	Q204	1.6667E-01	Q205	4.0000E-01	Q206	8.5000E-01
Q207	2.0000E-01	Q208	3.7000E-01	Q209	3.[illegible]000E-01	Q210	1.0000E-01	Q211	9.9990E-01	Q212	8.5984E-02
Q213	9.3130E-01	Q214	1.2575E-01	Q215	1.0900E-01	Q216	9.9990E-01	Q218	9.2180E-01	Q219	4.4039E-02
Q220	5.2200E-02	Q221	5.5120E-01	Q222	8.5984E-02	Q223	6.7540E-01	Q224	1.2575E-01	Q235	3.0000E-01
Q236	7.0000E-01	Q255	8.1000E-01	Q256	7.1520E-01	Q257	1.0000E-02	Q258	1.1000E-01	Q265	7.6520E-01
Q266	7.0560E-01	Q267	5.2893E-01	Q268	5.4250E-01	Q275	8.1020E-01	Q276	7.1830E-01	Q285	7.6520E-01
Q286	7.0380E-01	Q287	5.4250E-01	Q288	5.2893E-01	P201	4.7240E-01	P215	2.4997E-01	P217	8.6634E-01
P221	4.7240E-01	P230	2.4997E-01	A250	4.0000E-01	A251	-8.5000E-01	A260	-3.7000E-01	A261	3.0000E-01
A280	-3.0000E-01	A281	7.0000E-01	A200	3.[illegible]300E-02	A201	-2.0000E-02	A210	1.1398E-01	A211	-1.1400E-01
A215	4.5023E-02	A216	-4.6020E-02	A220	1.8660E-01	A221	-9.7410E-02	A227	-3.0000E-02	A230	-3.3100E-02
A231	-4.8000E-02	A232	-[illegible]500E-02	A233	-5.0000E-02	A237	-7.0000E-02	A238	1.1794E 02	A239	1.3206E 02
A240	1.0000E-01	A241	[illegible]009E-01	A242	-2.9861E-01	A243	2.9861E-01	A244	-1.0138E-01	A245	1.0138E-01
A252	6.0084E-01	A253	-1.0000E-02	A254	-1.0000E-02	A262	6.2224E-01	A263	-5.2224E-01	A264	5.2224E-01
A270	5.9389E 01	A271	-3.0000E-01	A272	-2.9389E-01	A273	-4.0000E-01	A282	2.2224E-01	A283	-2.2242E-02
A284	2.2242E-02	A292	-2.0000E-01	A293	-1.0000E-01	D250	-1.8776E 00	D251	-6.6667E-01	D260	-1.1274E 00
D261	1.8500E 00	D280	[illegible].4076E-02	D281	1.5000E 00	P00	1.0000E-01	P18	8.0[illegible]00E-02	P20	7.5800E-02
P23	5.5000E-01	P30	3.2300E-02	P37	1.5000E-01	P38	1.8660E-01	P43	2.0000E-01	P48	0.0
P57	0.0	P77	0.0	P78	0.0	P90	3.0000E-01	P95	1.8750E-01	P101	4.3060E-01
P104	4.3060E-01	P110	4.3057E-01	P114	4.3057E-01	DAC00	-4.7175E 02	DAC01	2.1378E-01	DAC02	-5.2835E 02
DAC03	5.0883E-02	DAC04	-5.9833E 00	DAC05	2.6396E 03	DAC06	7.5000E 00	DAC07	3.0335E 03	DAC08	-3.0000E 03
DAC09	-7.1000E 03	DAC10	1.4250E 00	DAC11	2.5116E 03	DAC12	-3.9388E 01	DAC13	2.4357E 03	DAC14	4.0062E 01
DAC15	1.0537E 00	DAC16	8.2210E 00	DAC17	2.1146E-01	DAC18	8.[illegible]000E 00	DAC19	5.1563E-02	DAC20	-8.3000E 00
DAC21	-7.5000E 00	DAC22	[illegible].7500E 00	DAC23	-7.4000E 00	DAC24	6.8731E 02	DAC25	6.8939E 02	DAC26	7.0327E 02
DAC27	9.0000E-01	DAC28	7.0402E 02	DAC29	2.0000E 00	DAC30	1.0100E 00	DAC31	1.2000E-01	DAC32	-2.0056E-02
DAC33	1.3467E-01	DAC34	1.0948E-01	DAC35	2.5000E-01	DAC36	2.4767E 03	DA00	-1.1794E-02	DA01	2.1378E-02
DA02	-1.3206E-02	DA03	5.0883E-03	DA04	-2.[illegible]916E-01	DA05	2.6396E-01	DA06	3.7500E-01	DA07	3.0335E-01
DA08	-2.0000E-01	DA09	-1.7750E-01	DA10	1.4250E-01	DA11	2.5116E-01	DA12	-3.9388E-01	DA13	2.4357E 01
DA14	4.0062E-01	DA15	1.0537E-02	DA16	4.11[illegible]5E-01	DA17	2.1146E-02	DA18	4.0000E-01	DA19	5.1563E-03
DA20	-4.1500E-01	DA21	-3.7500E-01	DA22	2.5250E-01	DA23	-3.7000E-01	DA24	4.5821E-01	DA25	4.5[illegible]59E-01
DA26	4.6855E-01	DA27	4.5000E-02	DA28	4.6935E-01	DA29	1.0000E-01	DA30	5.0500E-02	DA31	6.0000E-03
DA32	-2.0056E-02	DA33	1.3467E-01	DA34	1.0948E-01	DA35	2.5000E-01	DA36	2.4767E-01	A000	-1.0000E-01
A002	3.8300E-02	A005	-1.5000E-01	A007	1.8660E-01	A010	-2.000[illegible]	A012	8.0000E-02	A015	-5.5000E-01
A017	7.5800E-02	A040	0.0	A050	0.0	A080	0.0	A085	0.0	A090	3.[illegible]000E-01
A095	1.8750E-01	A100	4.3060E-01	A105	4.3060E-01	A110	-4.3057E-01	A115	-4.3057E-01	T51	-7.0000E-02
T52	-3.0000E-02	T80	-3.3100E-02	T82	-9.5900E-02	T83	-5.0000E-02	T84	-2.0000E-02	T85	-9.7410E-02
T86	-1.1400E-01	T87	-4.6020E-02	T88	-4.8000E-02	A003	-3.8300E-02	A004	8.6599E-01	A006	-4.[illegible]060E-01

A008	-3.8383E-01	A009	7.9338E-01	A011	-2.4257E-02	A014	-5.0007E-01	A016	6.4831E-02	A018	3.5175E-01
A019	-6.4831E-02	A020	2.3531E-01	A021	1.9467E-01	A022	4.9735E-02	A023	-7.5152E-03	A024	-1.9467E-01
A026	2.8132E-01	A028	6.1391E-03	A029	-2.8132E-01	A030	5.6036E-01	A032	-6.5000E-03	A033	-3.7000E-03
A034	8.6599E-01	A035	1.0138E-01	A036	-1.1398E-01	A037	8.6599E-01	A038	5.0000E-03	A039	6.0872E-01
A041	9.6470E-01	A042	6.0872E-01	A044	2.9000E-03	A045	-4.6023E-02	A046	2.9861E-01	A048	7.5825E-01
A049	-7.5557E-01	A051	1.1460E-01	A052	0.0	A053	3.1385E-01	A054	-1.1460E-01	A055	-8.3362E-02
A056	-4.3060E-01	A057	-6.0872E-01	A058	1.7328E-01	A059	-8.3356E-01	A060	1.3269E-02	A061	-6.0000E-02
A062	5.0007E-01	A063	-3.6386E-01	A064	-3.0612E-01	A065	-1.4830E-01	A066	-6.5542E-01	A068	4.9921E-01
A069	-8.6599E-01	A070	1.0000E-01	A071	0.0	A072	-8.6599E-01	A073	-3.4694E-01	A074	0.0
A075	-1.9412E-01	A076	1.9989E-01	A077	5.0007E-01	A078	3.2532E-01	A079	0.0	A081	3.1711E-01
A082	-6.0872E-01	A083	-3.2103E-01	A084	-7.2887E-01	A086	-2.9839E-01	A087	7.9338E-01	A088	4.2489E-01
A089	-8.1688E-01	A091	-2.5186E-02	A092	3.0612E-01	A093	-3.4145E-01	A094	-1.7083E-01	A096	-9.5844E-01
A097	-2.3531E-01	A099	6.0872E-01	A101	2.3234E-01	A102	-2.3234E-01	A103	-3.8235E-01	A104	6.3506E-02
A106	-7.5825E-01	A108	3.5891E-01	A109	-1.6942E-01	A111	5.2085E-01	A113	-1.3934E-01	A114	-3.1711E-01
A116	-1.7328E-01	A117	-7.9338E-01	A118	1.6716E-01	D000	-5.4820E-01	D002	-1.0000E-01	D005	-6.8493E 00
D007	-1.5000E-01	D010	-2.2499E 00	D012	-2.0000E-01	D015	-4.8532E 00	D017	-2.2000E-01	D040	-4.8940E 00
D050	0.0	D080	5.1111E-01	D085	0.0	D090	1.2337E 00	D095	1.2337E 00	D100	-1.7486E 00
D105	-4.1920E 00	D110	1.9989E 00	D115	4.9735E-01	DUMMY	0.0				

*** DSL/91 SIMULATION DATA *** 74.183 12:31:22.25

PARAM AXLE=0
END

DSL MESSAGE 20 NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91 SIMULATION TIME= 0.0 SECONDS. 74.183 12:31:22.26

DEBUG OUTPUT, BLOCK 3 AT TIME= 0.1000E-02

TIME	1.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	1.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	SHAPE1	-6.5000E-03	SHAPE2	-3.7000E-03	SHAPE3	5.0000E-03	SHAPE4	2.9000E-03
DEL1DT	1.0000E 01	DEL1	3.8300E-01	DEL2DT	1.5000E 01	DEL2	1.8660E 00	THETA1	6.0000E 01	THETA2	3.7500E 01
ERR1	1.0000E 00	ERR2	-6.0000E-01	DEW2DT	3.7000E 01	DEW2	1.5000E-01	YCRDT	8.0000E 01	YCR	2.5500E 00
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS3DT	1.0000E 04	RPS4	4.3057E 01	XPS4DT	1.0000E 04
DEW1DT	3.0000E 01	DEW1	3.5000E-01	PST1	2.1400E-01	PS12	2.0400E-01	PST3	1.6670E-02	PS14	-1.5000E-02
Z0	-2.3400E 01	THE0	2.090[illegible]E-03	PHI0	3.0000E-03	R0T0	-5.0000E 02	U01	1.2000E-01	U02	1.0100E 00
U03	9.0000E-01	U04	2.0000E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00	U14	1.7000E 00
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-8.3000E 00	TOFBR	8.0000E 03	TQRBR	7.1000E 03
MT1	-1.6430E 02	MT2	1.6430E 02	PDT0	-1.2000E-01	QDT0	9.0000E-02	U0	7.0400E 02	V0	1.3000E-01
W0	5.0000E-03	P0	2.0000E-02	Q0	-3.7000E-02	R0	1.1000E-02	F1	9.0000E-01	F2	8.0000E-01
F3	-3.0000E-01	F4	6.0000E-01	GB1	2.0000E-01	GB2	4.0000E-01	GB3	5.0000E-01	GB4	8.5000E-01
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	AIR	8.0000E 02	RF	8.1000E 04
TF	5.4300E 01	RR	5.0000E 04	LW	1.2850E 01	AIFW	5.8150E 00	AH1	2.0000E 02	AH2	2.0000E 02
AKT1	8.1200E 02	AKT2	8.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	8.0000E-02	CFCR	2.0000E 02
CCR	1.1000E 01	EP	[illegible].0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02
ESP	-6.0000E 00	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-01	EP2	-1.0000E-01	AIWF	7.3777E 00
AID	3.0000E-01	AKKR	4.1250E 05	AIWR	7.3777E 00	AKF	1.3300E 02	AKR	1.8500E 02	ALAMF	5.1000E 00
ORT	2.2000E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01	AKF1	5.2200E 01	AKF2	5.2200E 01
AKR3	1.0000E 02	AKF4	1.0000E 02	AKR3	1.0000E 02	AKR4	1.0000E 02	A	5.6300E 01	B	3.9000E 01
G	3.8640E 02	ZF	1.4000E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
AMU4	2.8700E-01	HF	7.2000E 00	HRC	4.7000E 00	CPRC	1.1000E-02	TANP	0.0	DELSWD	1.4250E 00
LH1	1.6500E 00	LH2	1.6500E 00	LH3	1.0000E 00	LH4	1.0000E 00	AXLE	0.0	BETA	2.5000E-01
S3P	-2.4465E 02	S4P	-3.[illegible]E 02	ZZ0001	0.0	ZZ0002	0.0	PHIR	0.0	PHIRD	0.0
DEL3	0.0	DEL3DT	0.0	SEL3	2.5000E-01	SEL3DT	6.9000E 01	SEL4	9.0000E-01	SEL4DT	7.0000E 01
FSA1	3.3100E 01	FSA2	4.8000E 01	FSA3	1.8610E 02	FSA4	1.8800E 02	F2F1	2.0000E 01	F2F2	9.7410E 01
F1F1	2.5000E 01	F1F2	2.5000E 01	F2R3	2.5000E 01	F2R4	9.0000E 01	F1R3	4.5000E 01	F1R4	4.5000E 01
AUXRL1	1.3269E 01	AUXRL2	-2.4257E 01	S1P	-5.4831E 01	S2P	-1.9467E 02	SMP	-8.3860E 02	S1	3.4330E 02
S2	2.1346E 02	S3	3.4451E 02	S4	2.5473E 02	ZET3	2.5000E-01	ZET3DT	6.9000E 01	ZET4	9.0000E-01
ZET4DT	7.0000E 01	Z1	-1.2253E 01	Z2	-1.0933E 01	Z3	-1.2389E 01	Z4	-1.1898E 01	H1	1.2253E 01
H2	1.0933E 01	H3	1.2389E 01	H4	1.1898E 01	RHO1	5.4679E-01	RHO2	1.9169E 00	RHO3	4.6147E-01
RHO4	5.5158E-01	FR1	4.3459E 02	FR2	1.5565E 03	FR3	5.5098E 02	FR4	1.1343E 03	FXU1	2.1540E 01
FXU2	-1.6027E 03	FXU3	-5.8431E 02	FXU4	-2.1708E 03	FYU1	1.9030E 01	FYU2	-2.4556E 02	FYU3	-3.5178E 01
FYU4	1.9524E 02	NPHIR	1.5292E 04	DEL1DD	-5.8369E 02	DEL2DD	-6.8848E 03	DEL3DD	-1.6700E 03	PHIRDD	1.8294E 01
SEL3DD	-4.7079E 02	SEL4DD	-2.7262E 03	F0	-3.1372E 04	AMSS1	-1.3012E 03	AMSS2	-3.0551E 04	DEW1DD	-3.3630E 02
DEW2DD	4.5095E 03	YCRDD	-1.5621E 05	U1	7.0310E 02	U2	7.0390E 02	U3	7.0331E 02	U4	7.0390E 02
V1	2.9824E-01	V2	3.1464E-01	V3	-7.5877E-01	V4	-7.4897E-01	W1	-7.3689E 00	W2	1.6545E 01
W3	7.0981E 01	W4	6.4024E 01	UG1	7.0329E 02	UG2	7.0393E 02	UG3	7.0346E 02	UG4	7.0404E 02
VG1	3.1034E-01	VG2	2.6550E-01	VG3	-9.7171E-01	VG4	-9.5305E-01	X11	2.3234E-01	X12	3.1711E-01
X13	2.4172E-01	X14	2.7235E-01	SLIP1	2.3234E-01	SLIP2	3.1711E-01	SLIP3	2.4172E-01	SLIP4	2.7235E-01
AM21	-7.3330E-01	AM22	1.0000E-01	AM23	7.2100E-01	AM24	-3.0000E-01	SI1	2.0056E-02	SI2	-1.3467E-01
SI3	-1.0948E-01	SI4	-2.5000E-01	U1P	-5.0371E-02	U2P	1.0417E 00	U3P	1.0743E 00	U4P	1.9183E 00
FC1	2.4410E 01	FC2	-1.6214E 03	FC3	-5.9093E 02	FC4	-2.1759E 03	RPS1DT	1.7486E 03	RPS2DT	4.1920E 03
DENOM	8.6539E 00	TERM	1.2752E 00	RPS4DT	2.3374E 03	RPS3DT	1.9172E 02	TT	1.0000E-04	THER1	1.0471E 00
THER2	6.5445E-01	THE1DT	2.4673E 03	THE2DT	2.4573E 03	ZZ0003	0.0	ZZ0004	0.0	Q200	5.2200E-02
Q201	5.5120E-01	Q202	1.5525E-01	Q203	6.[illegible]550E-01	Q204	1.6667E-01	Q205	4.0000E-01	Q206	8.5000E-01
Q207	2.0000E-01	Q208	3.7000E-01	Q209	3.0000E-01	Q210	1.0000E-01	Q211	[illegible].9990E-01	Q212	8.5984E-02
Q213	9.3130E-01	Q214	1.2575E-01	Q215	1.0000E-01	Q216	9.9990E-01	Q218	9.2180E-01	Q219	4.4034E-02
Q220	5.2200E-02	Q221	5.5120E-01	Q222	8.5984E-02	Q223	6.7540E-01	Q224	1.2575E-01	Q235	3.0000E-01
Q236	7.0000E-01	Q255	8.1000E-01	Q256	7.1520E-01	Q257	1.0000E-02	Q258	1.1000E-01	Q265	7.6520E-01
Q266	7.0560E-01	Q267	5.2693E-01	Q268	5.4250E-01	Q275	8.1020E-01	Q276	7.1830E-01	Q285	7.6520E-01

Q286	7.0380E-01	Q287	5.4250E-01	Q288	5.2893E-01	P201	4.7240E-01	P215	2.4997E-01
P217	8.6634E-01	P221	4.7240E-01	P230	2.4997E-01	A250	4.0000E-01	A251	-8.5000E-01
A260	-3.7000E-01	A261	3.0000E-01	A230	-3.0000E-01	A281	7.0000E-01	A200	3.8300E-02
A201	-2.0000E-02	A210	2.5000E-02	A211	-2.5000E-02	A215	9.0000E-02	A216	-9.0000E-02
A220	1.8660E-01	A221	-9.7410E-02	A227	-3.0000E-02	A230	-3.3100E-02	A231	-4.8000E-02
A232	-1.8610E-01	A233	-1.8800E-01	A237	-7.0000E-02	A238	1.1794E 02	A239	1.3206E 02
A240	1.0000E-01	A241	1.5000E-01	A242	-6.9000E-01	A243	6.9000E-01	A244	-7.0000E-01
A245	7.0000E-01	A252	6.0084E-01	A253	-1.0000E-02	A254	-1.0000E-02	A262	6.2224E-01
A263	-5.2224E-01	A264	5.2224E-01	A270	5.9389E-01	A271	-3.0000E-01	A272	-2.9389E-01
A273	-4.0000E-01	A282	2.2224E-01	A283	-2.2242E-02	A284	2.2242E-02	A292	-2.0000E-01
A293	-1.0000E-01	D250	-1.8776E 00	D251	-6.6667E-01	D260	-1.1274E 00	D261	1.8500E 00
D280	8.4076E-02	D281	1.5000E 00	P00	1.0000E-01	P18	0.0	P20	0.0
P23	0.0	P30	3.8300E-02	P37	1.5000E-01	P38	1.8660E-01	P43	0.0
P48	6.9000E-01	P57	2.5000E-02	P77	7.0000E-01	P78	9.0000E-02	P90	3.0000E-01
P95	1.8750E-01	P101	4.3060E-01	P104	4.3060E-01	P110	4.3057E-01	P114	4.3057E-01
DAC00	-4.7175E 02	DAC01	2.1378E-01	DAC02	-5.2825E 02	DAC03	5.0883E-02	DAC04	-5.983[illegible]
DAC05	2.6396E 03	DAC06	7.5000E 00	DAC07	3.0335E 03	DAC08	-8.0000E 03	DAC09	-7.1000E 03
DAC10	1.4250E 00	DAC11	2.4608E 03	DAC12	-3.9708E 01	DAC13	2.4357E 03	DAC14	3.9708E 01
DAC15	-3.1794E 00	DAC16	8.2210E 00	DAC17	2.1146E-01	DAC18	8.0000E 00	DAC19	5.1563E-02
DAC20	-8.3000E 00	DAC21	-7.5000E 00	DAC22	5.2500E 00	DAC23	-7.4000E 00	DAC24	6.8731E 02
DAC25	6.8939E 02	DAC26	7.0345E 02	DAC27	9.0000E-01	DAC28	7.0406E 02	DAC29	2.0000E 00
DAC30	1.0100E 00	DAC31	1.2000E-01	DAC32	-2.0056E-02	DAC33	1.3467E-01	DAC34	1.0948E-01
DAC35	2.5000E-01	DAC36	2.5538E 03	DA00	-1.1794E-02	DA01	2.1378E-02	DA02	-1.3206E-02
DA03	5.0883E-03	DA04	-2.9916E-01	DA05	2.6396E-01	DA06	3.7500E-01	DA07	3.0335E-01
DA08	-2.0000E-01	DA09	-1.7750E-01	DA10	1.4250E-01	DA11	2.4608E-01	DA12	-3.9708E-01
DA13	2.4357E-01	DA14	3.9708E-01	DA15	-3.1794E-02	DA16	4.1105E-01	DA17	2.1146E-02
DA18	4.0000E-01	DA19	5.1563E-03	DA20	-4.1500E-01	DA21	-3.7500E-01	DA22	2.6250E-01
DA23	-3.7000E-01	DA24	4.5821E-01	DA25	4.5959E-01	DA26	4.6896E-01	DA27	4.5000E-02
DA28	4.6937E-01	DA29	1.0000E-01	DA30	5.0500E-02	DA31	6.0000E-03	DA32	-2.0056E-02
DA33	1.3467E-01	DA34	1.0948E-01	DA35	2.5000E-01	DA36	2.5538E-01	A000	-1.0000E-01
A002	3.8300E-02	A005	-1.5000E-01	A007	1.8660E-01	A010	0.0	A012	0.0
A015	0.0	A017	0.0	A040	-6.9000E-01	A050	2.5000E-02	A080	-7.0000E-01
A085	9.0000E-02	A090	3.0000E-01	A095	1.8750E-01	A100	4.3060E-01	A105	4.3060E-01
A110	-4.3057E-01	A115	-4.3057E-01	T51	-7.0000E-02	T52	-3.0000E-02	T80	-3.3100E-02
T82	-1.8610E-01	T83	-1.8800E-01	T84	-2.0000E-02	T85	-9.7410E-02	T86	-2.5000E-02
T87	-9.0000E-02	T88	-4.8000E-02	A003	-3.8300E-02	A004	8.6599E-01	A006	-4.3060E-01
A008	-3.8388E-01	A009	7.9338E-01	A011	-2.4257E-02	A014	-5.0007E-01	A016	6.4831E-02
A018	3.5175E-01	A019	-6.4831E-02	A020	2.7235E-01	A021	1.9467E-01	A022	2.3374E-01
A023	-7.5152E-03	A024	-1.9467E-01	A026	2.4466E-01	A028	6.1391E-03	A029	-2.4466E-01
A030	5.3714E-01	A032	-6.5000E-03	A033	-3.7000E-03	A034	8.6599E-01	A035	7.0000E-01
A036	-2.5000E-02	A037	8.6599E-01	A038	5.0000E-03	A039	6.0872E-01	A041	9.5915E-01
A042	6.0872E-01	A044	2.9000E-03	A045	-9.0000E-02	A046	6.9000E-01	A048	2.3074E-01
A049	-8.2590E-01	A051	3.3444E-01	A052	-2.5000E-02	A053	3.1385E-01	A054	-3.3444E-01
A055	4.4890E-02	A056	-4.3060E-01	A057	-6.0872E-01	A058	4.7579E-01	A059	-7.9323E-01
A060	1.3269E-02	A061	-6.0000E-02	A062	5.0007E-01	A063	-3.6386E-01	A064	-2.4172E-01
A065	-1.4830E-01	A066	-8.3860E-01	A068	4.9921E-01	A069	-8.6599E-01	A070	1.0000E-01
A071	-6.5000E-02	A072	-8.6599E-01	A073	-3.7914E-01	A074	1.1440E-02	A075	-2.0894E-01
A076	1.9172E-02	A077	5.0007E-01	A078	3.5561E-01	A079	-1.1440E-02	A081	3.1711E-01
A082	-6.0872E-01	A083	-1.0236E-01	A084	-7.2887E-01	A086	-2.9839E-01	A087	7.9338E-01
A088	1.2394E-01	A089	-8.1688E-01	A091	-2.5186E-02	A092	2.4172E-01	A093	-3.4145E-01
A094	-1.4436E-01	A096	-9.5844E-01	A097	-2.7235E-01	A099	6.0872E-01	A101	2.3234E-01
A102	-2.3234E-01	A103	-3.6383E-01	A104	6.3506E-02	A106	-2.30[illegible]E-01	A108	3.4154E-01
A109	-1.6942E-01	A111	5.2085E-01	A113	-3.6199E-01	A114	-3.1711E-01	A116	-4.7579E-01
A117	-7.9338E-01	A118	4.5635E-01	D000	-5.8369E-01	D002	-1.0000E-01	D005	-6.8848E 00
D007	-1.5000E-01	D010	-1.6700E 00	D012	0.0	D015	1.8294E 00	D017	0.0
D040	-4.7079E-01	D050	-6.9000E-01	D080	-2.7262E 00	D085	-7.0000E-01	D090	1.2337E 00
D095	1.2337E 00	D100	-1.7486E 00	D105	-4.1920E 00	D110	1.9172E-01	D115	2.3374E 00
DUMMY	0.0								

2. PRESENTED HERE IS THE COMPUTER LISTING OF THE IBM 360/91 FORTRAN DIGITAL PROGRAM

2.1 SUBROUTINES

2.1.1 MAIN

PRESENTED HERE IS THE FORTRAN LISTING FOR THE MAIN SUBPROGRAM. THE FOLLOWING IS PERFORMED IN MAIN:

1) Communication initialization with the hybrid operator's station.

2) Reading of the input data deck.

3) Setting of potentiometers.

4) Simulation control via the interactive routines using the OPTION command.

```
C     VEHICLE HANDLING  MODEL C
      DIMENSION  ADC1(24),ADC2(4)
      DIMENSION  JDATE(3)
      DIMENSION ARIGH(10),ATRACK(2000),ASTEP(10)
      DIMENSION INCA(10),VINC(10)
      DIMENSION BVALUE(2)
      COMMON/START/ ZDUMMY(4)
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDE(2 ),IOP
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/INOUT/ INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,
     1SFIN(32),SFOUT(48),IPRT,ITMP(48)
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/SOLDAX/DELPHI(20),PHIFNT(20),DELTHE(20),THEFNT(20),NCAM,
     1 NCAS,PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/END/ STOP
      COMMON/LINE/ ALINE(3,6),TLINE(3,6),IL
      COMMON/IO/ DACPLA,ADCPLA,SCALDC,SCALAC
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAFCB,TDAECB
      COMMON /ECBBLK/AD2ECB,AD1ECB,CLSECB,CLRECB,ICECB ,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLFCB5,RLECB5
      COMMON/DELS/DELSWC
      COMMON/ALPHA/ALPH(20)
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
     1 ITRAA,ITRNA,ITRIA
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      COMMON/MICKEY/IRUNTB(002),VTB(002),SNLTB(002),SWBTB(002),DSWTB(002
     1  ),BTTB(002),DTB(002),EFFTB(002),DYTB(002),PSITB  (002),NRUN,
     1   YSPEC,PSIM,XPF
      COMMON/FIND/ORNAME(400),NCOM,RSVAL(002),IORDER(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1              AXI,CURVAV,ABBTV,AYMAX,RMAX,DELRET,DELPST,BETAMX,
     1              TIMBMP,GETDL,TIMIN5,         TSTEP ,    TVHTP
      EQUIVALENCE (ADC1(24),IN(24))      ,(ADC2(1),IN(25))
      EQUIVALENCE (TMNAME(1),FMNAME)
      EQUIVALENCE
     1    (PARAM( 1),AMS)     , (PARAM( 2),AMUF)  , (PARAM( 3),AMUR)    ,
     1    (PARAM( 4),ZF)      , (PARAM( 5),ZR)    , (PARAM( 6),A)       ,
     1    (PARAM( 7),B)       , (PARAM( 8),TF)    , (PARAM( 9),TR)      ,
     1    (PARAM(10),TS)      , (PARAM(11),AIX)   , (PARAM(12),AIY)     ,
     1    (PARAM(13),AIZ)     , (PARAM(14),AIXZ)  , (PARAM(15),AIF)     ,
     1    (PARAM(16),CF)      , (PARAM(17),RF)    , (PARAM(18),CFP)     ,
     1    (PARAM(19),AKF)     , (PARAM(20),ALAMF) , (PARAM(21),OFC)     ,
     1    (PARAM(22),OFT)     , (PARAM(23),CR)    , (PARAM(24),RP)      ,
     1    (PARAM(25),CRP)     , (PARAM(26),AKR)   , (PARAM(27),ALAMR)   ,
     1    (PARAM(28),ORC)     , (PARAM(29),ORT)   , (PARAM(30),AKRS)    ,
     1    (PARAM(31),RW)                          , (PARAM(33),OT)      ,
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)   , (PARAM(36),CA2)     ,
```

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     1    (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),AISW)    ,
     1    (PARAM(44),AKDL)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)     ,
     1    (PARAM(43),WG)      , (PARAM(40),ANL2)   , (PARAM(45),AKSL)
      EQUIVALENCE
     1    (PARAM(46),ANL1)    , (PARAM(47),AIFW)   , (PARAM(48),HDL)     ,
     1    (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)     ,
     1    (PARAM(52),ARBR)    , (PARAM(53),EPS1)   , (PARAM(54),EPS2)    ,
     1    (PARAM(55),PTBR)    , (PARAM(56),YSA1)   , (PARAM(57),YSA2)    ,
     1    (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),AKD)     ,
     1    (PARAM(61),TQDBR)   , (PARAM(62),AK)     , (PARAM(63),PIN)     ,
     1    (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)     ,
     1    (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)     ,
     1    (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)   ,
     1    (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)    ,
     1    (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)   ,
     1    (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)   ,
     1    (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)   ,
     1    (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)
      EQUIVALENCE
     1 (PARAM(88),B4),           (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
     1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
     1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),
     1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),
     1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),
     1    (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),
     1    (PARAM(106),S4PIN), (PARAM(107),PPRT)
     1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)
     1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),
     1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)
     1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)
     1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)
     1   ,(PARAM(124),TSW)
      EQUIVALENCE
     1  (PARAM(130),AMCP),(PARAM(131),ESP),(PARAM(132),AKSL1),
     1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),
     1  (PARAM(136),CCR),(PARAM(137),CPCR),(PARAM(138),AP),
     1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),
     1  (PARAM(142),ERR2),
     1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),FRIM),
     1    (PARAM(146),RWR)
     1    ,(PARAM(196),EPSK1),(PARAM(197),EPSK2)
      EQUIVALENCE
     1    (PARAM(284),HFC),(PARAM(285),HRC)
C#####################################
C### PARAM(290)-(295) ADDED 8/11/72 ###
C#####################################
      EQUIVALENCE
     1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
     1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
      EQUIVALENCE
     1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),
     1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),
     1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),
     1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),
     1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),
     1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),
     1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),
     1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),
     1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),
     1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))
```

```
      EQUIVALENCE (NAMSUR(1),ZDUMMY(1))
      EQUIVALENCE (DVALUE(1),ZDUMMY(1))
      REAL*8 NAMSUR(2),STOP,NAMEA(10)
      REAL*8 ZDUMMY
      REAL*8 TABVAR(9,7)
      REAL*8 QUES,CHANGE,READ,CONTRL,RETURN
      REAL*8 OPTION(15),OPTEST
      REAL*8 BLANK,SELECT,ASELT(15),REMOVE,RESET
      REAL*8 NMES,NTESTP,NTESTO
      REAL*8 NADCL,NDACL,NDUMP,NPARM,NNPC,NPLOT,NSTAT,NSTD
      REAL*8 NTRACK,NTM,NTIMD,NTABLE
      REAL*8 OUTNAM(21),NX,NOUT,NTERM,NRESR,NIC,NADCA
      REAL*8 NXM,UNNAM(3),MODENA(4)
      REAL*8 ORNAME,FMNAMF
      REAL*8 NLA
      REAL*8 NDACA,NMULT,CNAME,NII,NFF
      REAL*4 VALMR(20),FINLMR(20)
      REAL*4 TMNAME(2)
      REAL*4 FNUMA(10)
      REAL*4 IOUT(48),IN,ITMP,SCALAC(28),SCALDC(48)
      INTEGER*4 WRDVNT(9)
      INTEGER*4 INDFXA(10)
      INTEGER*4   OSECB       ,DONECB ,SLECB5,RLECB5
      INTEGER*4 ITABI(9)
      INTEGER*4 ITAPP(9),TABNUM,ITNAM(9)
      INTEGER*2 INDVAR(9,7)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50)
        INTEGER*2 LOCAT(20),LOOPN(20)
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN
      INTEGER*2 DEVICE(21),IORDER,IMODE(20)
      INTEGER*2 DACNUM,ADCNUM,DACPLA(48),ADCPLA(28)
      INTEGER*2 NAMDAC(48),NAMADC(28),IDAC(48),IADC(28)
      DATA QUES/'?    '/
      DATA BLANK/' '/
      DATA OUTNAM/'STD','TM','TABLE',17*' '/
      DATA NMES,NTESTP,NTESTO/'MES','TEST','TESTO'/
      DATA RESET,REMOVE/'RESET   ','REMOVE  '/
      DATA DEVICE/2,2,3,17*0/
      DATA IMODE/1,1,3,17*0/,NXM/'XM'/
      DATA UNNAM/'L.......','T.......','B.......'/
      DATA MODENA/'S.......','XEQ.....','M.......','A.......'/
      DATA NLA/'LA'/
      DATA NX,NOUT,NTERM,NRESR,NIC/'X','OUTPUT','TERM','RE-STR','IC'/
      DATA NADCA,NDACA,NII,NFF/'ADCA','DACA','I','F'/
      DATA NMULT,NADCL,NDACL/'MULTI','ADCL','DACL'/
      DATA NDUMP,NPARM,NPLOT,NSTAT/'DUMP','PARM','PLOT','STAT'/
      DATA NSTD,NTRACK,NTM,NTIMD/'STD','TRACK','TM','T+D'/
      DATA NTABLE,NNPC/'TABLE','PC'/
      KEYBD=5
      ITTY=6
      LPRNT = 0
      ICDRD  = 1
      LAST=72
      LPTR   =2
      CALL TYPER2(KEYBD,ITTY,LPRNT)
      CALL SETUP(ITTY,ICDRD)
      DO 10 I=1,48
      IOUT(I)=0
   10 CONTINUE
      IPT=0
```

```
      IKEEP=0
      JIN=0
      ICDPN=7
      IDACK=0
      TABNUM=9
      MOPU=6
      LRUNS=0
      IRUNS=1
      ICT=0
      LSTART=1
      LAST=72
      DTIN=.02
      ADCNUM=28
      DACNUM=48
      SAVHTP=100
      ITRUNS=0
      REALT=1.
      ONTIM=1000.
      N1=295
      N2=119
      RTSW=1
         RBSW   = 0
         OPEN   = 0
      ICDPN  =7
      WRITE(ITTY,11)
      WRITE(ITTY,10070)
      WRITE(ITTY,10120)
      READ(KEYBD,11000) LL
      CALL SACN(1,ISACNE)
      CALL SAMO(1,ISAMOE)
      CALL SLMO(3,ISLMOE)
      CALL SLMO(1,ISLMOE)
11000 FORMAT(I1)
10120 FORMAT(1H ,18HTYPE CR WHEN READY)
10070 FORMAT(1HC,27HENGAGE PATCH PANEL FOR TEST)
   11 FORMAT(T10,'HYBRID VEHICLE HANDLING PROGRAM')
 8888 CONTINUE
      XPF=XIN
      YSPEC=YIN
      NRUN=1
 3333 FORMAT(20A4)
      DO 6140 I=1,48
      ITMP(I)=0
 6140 CONTINUE
      READ(ICDRD,3333) (ALPH(I),I=1,20)
      READ(ICDRD, 900) (PHIFNT(I),I=1,7)
      READ(ICDRD, 900) (THFFNT(I),I=1,7)
      READ(ICDRD,900)  (PSIFNT(I),I=1,7)
      READ(ICDRD,900) (PHIRR(I),I=1,7)
      READ(ICDRD,900)  (THERR(I),I=1,7)
      READ(ICDRD,900) (PSIRR(I),I=1,7)
      NTF=1
  200 READ(ICDRD,900)   PBF(NTF),TQBF(NTF)
      IF(PBF(NTF).GE.99999.0)GO TO 210
      NTF=NTF+1
      GO TO 200
  210 NTF=NTF-1
      NTR=1
  220 READ(ICDRD,900)  PBR(NTR),TQBR(NTR)
      IF(PBR(NTR).GE.99999.0) GO TO 230
```

```
      NTR=NTR+1
      GO TO 220
  230 NTR=NTR-1
      NFA=1
  280 READ(ICDRD,900) GAMF(NFA),AFA(NFA)
      IF(GAMF(NFA).GE.99999.0) GO TO 290
      NFA=NFA+1
      GO TO 280
  290 NFA=NFA-1
  900 FORMAT(8E10.0)
      READ(ICDRD,8750)  (ASELT(I),I=1,15)
      READ(ICDRD,1011)  CHANGE,READ,RETURN,CONTPL
      READ(ICDRD,8750)  (OPTION(J),J=1,15)
C     THIS ROUTINE SETS UP TRACK NAME ARRAY
      ITRA=0
  130 CALL UNFORM(ICDRD,1)
      IF(IWRDCT.EQ.0)  GO TO 120
      DO 110 I=1,IWRDCT
      CALL FINDNM(K,J,I,&110)
      ITRA=ITRA+1
      ITRAA(ITRA)=K
      ITRNA(ITRA)=J
      ITRIA(ITRA)=INDEXA(I)
  110 CONTINUE
      GO TO 130
  120 CONTINUE
C     THIS ROUTINE SETS UP TABLE NAME ARRAY
      DO 101 JJ=1,7
      CALL UNFORM(ICDRD,1)
      TABNUM=IWRDCT
      DO 102 LL=1,TABNUM
      TABVAR(LL,JJ)  =  NAMEA(LL)
      INDVAR(LL,JJ)  =  INDEXA(LL)
  102 CONTINUE
      WRDVNT(JJ)  =  TABNUM
  101 CONTINUE
 8750 FORMAT(1X,5A8)
 1011 FORMAT(1X,4A8)
 8101 FORMAT(A8)
 8031 FORMAT(1H0,'ERROR')
 8764 FORMAT(1H0,'THIS OPTION HAS NOT BEEN PROGRAMED YET')
      DO 1701 I=1,120
      IPOTAD(I)=100000
      IPOT(I)=100000
 1701 CONTINUE
      DO 1028 I=1,500
      READ(ICDRD,50,END=32)  NOPARM,PARVAL
   50 FORMAT  (I3,1X,G20.6)
      IF(NOPARM.EQ.304)  GO TO 2222
 1100 PARAM(NOPARM)=PARVAL
 1028 CONTINUE
 32   WRITE(ITTY,33)
   33 FORMAT('  END OF CARDS')
 2222 CONTINUE
      DO 9007 I=1,48
      CALL UNFORM(ICDRD,1)
      CALL FINDNM(K,J,1,&9007)
      NAMDAC(I)=J
      DACPLA(I)=K
      SCALDC(I)=FNUMA(1)
```

```
      IDAC(I)=INDEXA(1)
 9007 CONTINUE
      DO 1269 I=1,28
      CALL UNFORM(ICDRD,1)
      CALL FINDNM(K,J,1,&1269)
      NAMADC(I)=J
      ADCPLA(I)=K
      IADC(I)=INDEXA(1)
      SCALAC(I)=FNUMA(1)
 1269 CONTINUE
      CALL POTSET
      CALL SBPG4
 1689 CONTINUE
      DO 661 I=1,NCOM
 661  CONTINUE
C ***********************
C *                     *
C * INITIALIZATION PASS *
C *                     *
C ***********************
C        1 LOAD JDATE ARRAY
C        2 WRITE  TIME AND DATE
      CALL  IDATE(JDATE)
      CALL TIMDAT(JDATE,ITTY)
C************************************************************************
C
C **************
C *            *
C * OPTION TEST * - ENTER A NAME FROM KEYBD (OPTEST)
C *            *
C **************
C
C        1 IF OPTEST IS AN OPTION KEYWORD PASS CONTROL TO OPTION EXECUTI
C        2 IF OPTEST IS AN OUTPUT KEYWORD PASS CONTROL TO OUTPUT ARRAY A
C        3 IF OPTEST IS IN THE ANAME ARRAY WRITE ITS PRESENT AND INITIAL
C        4 IF OPTEST IS EQUAL TO RESET  GO TO RESET ROUTINE
C        5 IF NONE OF THE ABOVE ENVOKE ERROR MONITOR
C
 8749 WRITE(ITTY,8754)
 8754 FORMAT(1H0,'OPTION')
      READ(KEYBD,1031) OPTEST
 1031 FORMAT(1A8)
 8450 CONTINUE
      LSTART=1
      LAST=80
      SELECT=OPTEST
      LVEC=1
      DO 8756 IOR=1,15
      IF(OPTION(IOR).EQ.OPTEST) GO TO 8758
 8756 CONTINUE
      IF(OPTEST.EQ.REMOVE) GO TO 8234
      IF(OPTEST.EQ.RESET) GO TO 8230
      IF(OPTEST.EQ.NXM) GO TO 8802
      DO 8765 IS=1,15
      IF(OPTEST.EQ.ASELT(IS)) GO TO 720
 8765 CONTINUE
      GO TO 8768
C
C************************************************************************
C
```

```
C ********************
C *                  *
C * OPTION EXECUTIVE * - CONTROL IS PASSED FROM OPTION TEST
C *                  *
C ********************
C     IF OPTEST IS EQUAL TO:
C        1 X - TRANSFER CONTROL TO EXECUTION REGION
C        2 IC - TRANSFER CONTROL TO EXECUTION REGION
C        3 OUTPUT - TRANSFER CONTROL TO OUTPUT ARRAY ASSEMBLER
C        4 TERM - TRANSFER CONTROL TO TERMINAL REGION
C        5 ADCA - ALTER ADC ARRAY
C        6 DACA - ALTER DAC ARRAY
C        7 F - FLOATING POINT OPERATIONS
C        8 I - INTEGER OPERATIONS
C        9 MES - SEND MESSAGE TO LINE PRINTER
C       10 TEST - EXECUTE TEST ROUTINE
C       11 RF-STR - RESTART FLIGHT PHASE SEQUENCER
C       12 IF NONE OF THE ABOVE RETURN TO OPTION TEST
 8758 CONTINUE
      IF(OPTEST.EQ.NX) GO TO 8802
      IF(OPTEST.EQ.NTERM) GO TO 8809
      IF(OPTEST.EQ.NIC) GO TO 8802
      IF(OPTEST.EQ.NRESR) GO TO 8888
C
      IF(OPTEST.NE.NADCA) GO TO 5000
C ##### --- ADC ROUTINE ---#####
      CALL ADCA(ADCNUM,NAMADC,IADC,SCALAC,ADCPLA,ITTY,KEYBD)
 5000 CONTINUE
      IF(OPTEST.NE.NII.AND.OPTEST.NE.NFF) GO TO 5010
C#####---ALTER OR READ DATA LIST ---#####
      CALL RDWRT(OPTEST)
 5010 CONTINUE
      IF(OPTEST.NE.NDACA) GO TO 5020
C #####---DAC ROURINE ---#####
      CALL DACA (DACNUM,NAMDAC,IDAC,SCALDC,DACPLA,ITTY,KEYBD)
 5020 CONTINUE
      IF(OPTEST.NE.NMES) GO TO`5035
C #####--- MESSAGE ROUTINE ---#####
      CALL MESRTN(ITTY,KEYBD,RETURN,LPTR)
 5035 CONTINUE
      IF(OPTEST.NE.NMULT) GO TO 5040
C#####--- MULTI RUN ---#####
      CALL MULTRN (ITTY,LOCAT,LOOPN,VALMR,FINLMR,ICT,IRUNS)
 5040 CONTINUE
      IF(OPTEST.NE.NTESTP) GO TO 5050
C#####--- TEST OPTION ---#####
      CALL TESTP(KEYBD,ITTY,NCOM,ORNAME,IODDEF,RVALUE,RSVAL,REALT)
 5050 CONTINUE
      GO TO 8749

C**********************************************************************
C
C **************************
C *                        *
C * OUTPUT ARRAY ASSEMBLER * - CALLED FROM THE OPTION TEST OR EXECUTIVE
C *                        *
C **************************
C
  720 WRITE(ITTY,700)
  700 FORMAT(1H ,'UNIT,MODE')
```

```
      CALL UNFORM(5,1)
      DO 705 IOU=1,3
      IF(UNNAM(IOU).EQ.NAMEA(1)) GO TO 710
  705 CONTINUE
      WRITE(ITTY,715)
  715 FORMAT(1H ,'FOR UNIT ENTER  L (LIN PT), T (TELE), B (BOTH)')
      GO TO 720
  710 DO 725 MODE=1,4
      IF(MODENA(MODE).EQ.NAMEA(2)) GO TO 730
  725 CONTINUE
      WRITE(ITTY,735)
735   FORMAT(1H ,'FOR MODE ENTER  A (ALL), S (SING.), M (MULTI), XEQ (EX
     1ECUTION)')
      GO TO 720
  730 CONTINUE
C
 8215 CONTINUE
      IF(SELECT.NE.NLA) GO TO 2005
      CALL ARAST
 2005 CONTINUE
      IF(SELECT.NE.NTABLE) GO TO 2010
C#####--- TABLE SET UP ---#####
      CALL TABLES(ITTY,KEYBD)
 2010 CONTINUE
      IF(SELECT.NE.NTRACK) GO TO 2020
C#####--- TRACK ROUTINE ---#####
      CALL TRACKS(ITTY,KEYBD,DTIN)
 2020 CONTINUE
C#####--- SET UP OUTPUT NAME ARRAY ---#####
      IF(MODE.NE.2) GO TO 670
      OUTNAM(21)=OPTEST
      DEVICE(21)=IOU
      GO TO 8253
  670 DO 741 JJ=1,20
      IF(OUTNAM(JJ).EQ.OPTEST) GO TO 740
  741 CONTINUE
      DO 745 JJ=1,20
      IF(OUTNAM(JJ).EQ.BLANK) GO TO 740
  745 CONTINUE
  740 OUTNAM(JJ)=OPTEST
      IMODE(JJ)=MODE
      DEVICE(JJ)=IOU
      GO TO 8749
C#####--- REMOVE SINGLE VARIABLE ---#####
 8234 CONTINUE
      WRITE(ITTY,350)
  350 FORMAT(1H ,'WHAT')
      READ(KEYBD,1031) OPTEST
      DO 7350 I=1,20
      IF(OUTNAM(I).EQ.OPTEST) OUTNAM(I)=BLANK
 7350 CONTINUE
      GO TO 8749
C#####--- RESET OUTPUT NAME ARRAY ---#####
C
C     LOAD OUTPUT NAME ARRAY WITH BLANKS
 8230 DO 8231 I=1,20
      OUTNAM(I)=BLANK
 8231 CONTINUE
      GO TO 8749
C***************************************************************************
```

```
C
C *******************
C *                 *
C * EXECUTION REGION * - CONTROL IS TRANSFERED FROM OPTION EXECUTIVE
C *                 *
C *******************
 8802 CONTINUE
C        1 FILL BVALUE ARRAY WITH INITIAL CONDITIONS
C        2 SET POTS
C        3 SET DACS
C        4 EQUIVALENCE + STORE IC
C        5 IF REAL TIME IS CALLED ENTER FLAGE
C        6 WRITE TIME,DATE, AND RUN NUMBER
C        7 CHANGE AIALOG MODE
C     SAVHTP INIALIZED TO PARAM(129) AFTER ISN 10
      IF(OPTEST.EQ.NIC) GO TO 170
      LRUNS=LRUNS+1
      ITRUNS=ITRUNS+1
  170 CONTINUE
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 165
      DO 160 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 160
      KTEMP=LRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  160 CONTINUE
  165 CONTINUE
      IF(SAVHTP.EQ.PARAM(129)) GO TO 500
      CALL VHTPIC
      I=IFIX(PARAM(129))
      IF(I.EQ.0) I=7
      TABNUM = WRDVNT(I)
      DO 40  J=1,TABNUM
      NAMEA(J) = TABVAR(J,I)
      INDEXA(J) = INDVAR(J,I)
   40 CONTINUE
      DO 100 I=1,TABNUM
      CALL FINDNM(K,J,I,&100)
      ITABI(I)=INDEXA(I)
      ITNAM(I)=J
      ITABP(I)=K
  100 CONTINUE
  500 CONTINUE
      SAVHTP = PARAM(129)
      IF(REALT.GT..5) IRT=1
      RTSW=IFIX(REALT)
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 155
      DO 150 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 150
      KTEMP=LRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  150 CONTINUE
  155 CONTINUE
      CALL POTSET
      IF(REALT.LT..5) GO TO 75
      DO 1702 I=1,120
      IF(IPOT(I).EQ.IPOTAD(I)) GO TO 1702
      CALL POTCHK(I,IPOT(I),3,&8152,&8152)
      IPOTAD(I)=IPOT(I)
 1702 CONTINUE
   75 CONTINUE
```

```
      CALL SBPG4
      CALL SAMO(6,ISAMOE)
      IKEEP=ISAMP-1
      IDACK=0
      JIN=0
      IF(IOR.EQ.12) GO TO 8749
      CALL WAITEU (200)
      IF(LRUNS.GT.1) GO TO 1888
      CALL TIMDAT(JDATE,ITTY)
      CALL TIMDAT(JDATE,LPTR)
      WRITE(LPTR,9050) ITRUNS
      WRITE(ITTY,9050) ITRUNS
 9050 FORMAT(1H0,'RUN ',I3,' HAS STARTED'/1H0,
     1 'OUTPUT BELOW')
 1888 CONTINUE
      CALL CLOCK(NTIME1)
C
C
C#####--- ENTER REAL TIME PART ---#####
C     AT THIS POINT THE RTMON SUBPROGRAM IS ACTIVATED
C     RTMON INTURN EXECUTS THE MODLE
C
      IVHTP = PARAM(129) + .5
      CALL RTMON
      CALL CMPVAR
C     WHEN EXECUTION TAKES PLACE THE FOLLOWING TAKES PLACE:
C         1 REAL TIME PRECENT IS CALCULATED
C         2 CHANGE ANALOGE MODE
C         3 CALCULATE RUN MODE
C         4 EXECUTE SELECTED OUTPUTS FOR GIVEN MODE
C                B MODE=3 FOR MULTI-RUN
C                A MODE=1 FOR SINGLE RUN
C         5 IF MODE IS EQUAL TO TWO GO TO OPTION TEST
C         6 IF PROGRAM IS IN MULTI-RUN IRUNS IS GREATOR THAN LRUNS
C                A INCREMENT VARIABLES SELECTED
C                B EXECUTE NEXT RUN
C         7 END OF RUN LRUNS=0,ITRUNS=1
C         8 RETURN TO OPTION TEST
C
C
      CALL CLOCK(NTIME2)
      NRTIME=NTIME2-NTIME1
      IF(NRTIME.GT.1) RTPER= (TIME*10000.)/FLOAT(NRTIME)
      MODE=1
      IF(OPTEST.EQ.NXM) MODE=3
      DO 3210 I=1,48
      IF(I.EQ.19.OR.I.EQ.20) ITMP(I)=IOUT(I)
 3210 CONTINUE
      CALL LBDAFP(OC,47,DACO,ILBDAP)
      CALL TLDA
      EFF=0.0
      IF(ADOUT.NE.0.0) EFF=ANOUT/ADOUT
 8253 CONTINUE
      DO 8943 I=1,20
      IFP=1
      ILA=2
      IF(MODE.NE.2) GO TO 555
      CNAME=OUTNAM(21)
      IF(DEVICE(21).EQ.1) ILA=1
      IF(DEVICE(21).EQ.2) IFP=2
```

```
      I=20
      GO TO 550
  555 IF(IMODE(I).EQ.4) GO TO 560
      IF(IMODE(I).EQ.MODE) GO TO 560
      GO TO 8943
  560 CNAME=OUTNAM(I)
      IF(CNAME.EQ.BLANK) GO TO 8943
      IF(DEVICE(I).EQ.1) ILA=1
      IF(DEVICE(I).EQ.2) IFR=2
  550 CONTINUE
      DO 8946 K=IFR,ILA
      IF(K.EQ.1) MOPU=LPTR
      IF(K.EQ.2) MOPU=ITTY
      IF(CNAME.NE.NADCL) GO TO 3000
C #####--- LIST ADC ARRAY ---#####
      CALL LSTADC(ADCNUM,MOPU,NAMADC,IADC,SCALAC,ORNAME)
      GO TO 8946
 3000 CONTINUE
      IF(CNAME.NE.NDACL) GO TO 3010
C#####--- LIST DAC ARRAY ---#####
      CALL LSTDAC(DACNUM,MOPU,IDAC,SCALDC,NAMDAC,ORNAME)
      GO TO 8946
 3010 CONTINUE
      IF(CNAME.NE.NDUMP) GO TO 3020
C#####--- DUMP ---#####
      CALL DUMP (MOPU,NCOM,IORDER,ORNAME,BVALUE)
      GO TO 8946
 3020 CONTINUE
      IF(CNAME.NE.NIA) GO TO 3030
      CALL ARAWT(MOPU,BVALUE,ORNAME)
      GO TO 8946
 3030 CONTINUE
      IF(CNAME.NE.NNPC) GO TO 3040
      GO TO 8946
 3040 CONTINUE
      IF(CNAME.NE.NPLOT) GO TO 3050
      WRITE(ITTY,8764)
      GO TO 8946
 3050 CONTINUE
      IF(CNAME.NE.NSTAT) GO TO 3060
      WRITE(ITTY,8764)
      GO TO 8946
 3060 CONTINUE
      IF(CNAME.NE.NSTD) GO TO 3070
C#####--- STD OUTPUT ---#####
C#####--- STD OUTPUT ---#####
      WRITE(ITTY,2345) AXAVE,TIMDEC,CUVRAT,BTDMX,BETAMX,DELBET,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1' AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1' FTRQMAX=',F8.3,' RTRQMAX=',F8.3/)
      GO TO 8946
 3070 CONTINUE
      IF(CNAME.NE.NTABLE) GO TO 3080
C#####--- TABLE OUTPUT ---#####
      CALL TABLEO(MOPU,ORNAME,LRUNS,ITRUNS,BVALUE)
      GO TO 8946
 3080 CONTINUE
```

```
      IF(CNAME.NE.NTESTO) GO TO 3085
C#####---TEST VALUE OUTPUT -----#####
      GO TO 8946
 3085 CONTINUE
      IF(CNAME.NE.NTIMD) GO TO 3090
C#####---DATE---#####
      CALL TIMDAT(JDATE,MOPU)
      GO TO 8946
 3090 CONTINUE
      IF(CNAME.NE.NT4) GO TO 3100
      CALL FRMONT(MOPU,ORNAME,NAMDAC,IDAC,PHIMAX)
      GO TO 8946
 3100 CONTINUE
      IF(CNAME.NE.NTRACK) GO TO 3110
C#####--- TRACK OUTPUT ---#####
      CALL TRACC(MOPU,ORNAME,DTIN)
      GO TO 8946
 3110 CONTINUE
 8946 CONTINUE
 8943 CONTINUE
      IF(MODE.EQ.2) GO TO 8749
      IF(OPTEST.EQ.NO) GO TO 8152
 8150 IF(IRUNS.EQ.LRUNS) GO TO 8152
      GO TO 8802
 8152 CONTINUE
      LRUNS=0
      GO TO 8749
C
C*****************************************************************************
C
C#####--- OPTION ERROR ---#####
 8768 CONTINUE
      WRITE(ITTY,8031)
      READ(KEYBD,8101) OPTEST
      IF(OPTEST.NE.QUES) GO TO 8450
      WRITE(ITTY,8762)
 8762 FORMAT(1H0,'OPTION NOT FOUND'/1H0,
     1'TO XEQ. PROGRAM          TYPE X'/1H0,
     1'TO TERMINATE PROGRAM     TYPE TERM'/1H0,
     1'FOR MULTIPLE RUNS        TYPE MULTI'/1H0,
     1'FOR TEST RUN OR ABEND    TYPE TEST'/1H0,
     1'TO ALTER DAC ARRAY       TYPE DACA'/1H0,
     1'TO ALTER ADC ARRAY       TYPE ADCA'/1H0,
     1'TO SET IC ONLY           TYPE IC'/1H0,
     1'TO SEND MESSAGE TO LP TYPE MES'/1H0,
     1'FOR TIME AND DATE                 TYPE T+D'/1H0,
     1'TO DUMP DATA LIST                 TYPE DUMP'/1H0,
     1'FOR STANDARD OUTPUT               TYPE STD'/1H0,
     1'FOR TEST VARIABLES                TYPE TESTO'/1H0,
     1'TO RESET  (NO OUTPUT)             TYPE RESET'/1H0,
     1'TO TRACK REAL TIME VARIABLES      TYPE TRACK'/1H0,
     1'FOR TABULAR OUTPUT                TYPE TABLE'/1H0,
     1'TO LIST DAC ARRAY                 TYPE DACL'/1H0,
     1'TO LIST ADC ARRAY                 TYPE ADCL'/1H0,
     1'FOR TERMINATION MONITOR           TYPE TM')
      GO TO 8749
C#####--- TERMINATE #####
 8809 OSFCB=0
      CALL TIMDAT(JDATE,ITTY)
      IF(IRT.NE.1) GO TO 5607
```

```
      CALL HPOST( DONECB,'J007' )
      CALL WAITRT(OSECB)
 5607 CONTINUE
      WRITE(ITTY,8821)
 8821 FORMAT(1H0,'PROGRAM TERMINATED')
      CALL RACN(1,IRACNE)
      CALL WRTOFF
      CALL RDOFF
      STOP
      END
```

2.1.2 SBPG4

PRESENTED HERE IS THE FORTRAN LISTING FOR THE INITIALIZATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN SBPG4:

1) Calculation of initial conditions using input data.

2) Initialization of digital-to-analog converters to their time = 0 values.

```
C       SUBROUTINE SBPG4
        SUBROUTINE SBPG4
C       THIS SUBROUTINE CALCULATES INITIAL CONDITIONS
        DIMENSION NAMEX(124),NAME(289)
        COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
        COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
        COMMON/SPLTAX/SPSR3,CPSR3,SPSR4,CPSR4,SCR3,SCR4,TBCR3,TBCR4,TBSR3,
     1   TBSR4,TRSR3,TRSR4,TRCR3,TRCR4,PSR3,PSR4,IAX
        COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
        COMMON/FEES/FEE1,FEE2,THE1,THE2
        COMMON/FRIDAY/BTVMAX,BTVTB(100)
        COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
        COMMON/EES/O1,O2,O3,E4,E5,E6
        COMMON/ALPHA/ALPH(20)
        COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1     AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1     GR2,CIP,CIVP,RZF,PZR,A2T,CA20,CA23,              ANGNL,ANGNLO
     1     ,TRO2,TFO2,TSO2,G,THRD,TWN7
        COMMON/TIMBLK/JJTIME,TIME,DT
        COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
        COMMON/XX/IDAC(48),IADC(32)
        COMMON/INOUT/INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,SFIN(32),
     1      SFOUT(48),IPRT,ITMP(48)
        COMMON/UVW/VC,UIN
        COMMON/XYZ/ NUMBR
        COMMON/OPSW/IBSW
        COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1     YO,ZO,THEO,PHIO,PSIO
        COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
        COMMON/MICKEY/IRUNTB(002),VTB(002),SNLTB(002),SNRTB(002),DSWTB(002
     1  ),BTTB(002),DTB(002),EFFTB(002),DYTB(002),PSITB (002),NRUN,
     1   YSPEC,PSIM,XPF
        COMMON/XBS/XB(15),NS(4,15),DELX(4),XI(4),NNN
        COMMON/NONAME/XEND,O,EXIT2
        COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
        COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTP,DEL,
     1              AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1              TIMBMP,GETDL,TIMIN5,          TSTEP ,   IVHTP
        EQUIVALENCE
     1    (PARAM( 1),AMS)     , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)    ,
     1    (PARAM( 4),ZF)      , (PARAM( 5),ZR)     , (PARAM( 6),A)       ,
     1    (PARAM( 7),B)       , (PARAM( 8),TF)     , (PARAM( 9),TR)      ,
     1    (PARAM(10),IS)      , (PARAM(11),AIX)    , (PARAM(12),AIY)     ,
     1    (PARAM(13),AIZ)     , (PARAM(14),AIXZ)   , (PARAM(15),AIR)     ,
     1    (PARAM(16),CF)      , (PARAM(17),RF)     , (PARAM(18),CFP)     ,
     1    (PARAM(19),AKF)     , (PARAM(20),ALAMF)  , (PARAM(21),OFC)     ,
     1    (PARAM(22),OFT)     , (PARAM(23),CR)     , (PARAM(24),RR)      ,
     1    (PARAM(25),CRP)     , (PARAM(26),AKR)    , (PARAM(27),ALAMR)   ,
     1    (PARAM(28),ORC)     , (PARAM(29),ORT)    , (PARAM(30),AKRS)    ,
     1    (PARAM(31),RW)                           , (PARAM(33),OI)      ,
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)     ,
     1    (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),AISW)    ,
     1    (PARAM(44),AKDL)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)     ,
     1    (PARAM(43),WG)      , (PARAM(40),ANL2)   , (PARAM(45),AKSL)
        EQUIVALENCE
     1    (PARAM(46),ANL1)    , (PARAM(47),AIFW)   , (PARAM(48),HDL)     ,
     1    (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)     ,
     1    (PARAM(52),ARBR)    , (PARAM(53),EPS1)   , (PARAM(54),EPS2)    ,
```

```
1    (PARAM(55),PTBR)     , (PARAM(56),YSA1)    , (PARAM(57),YSA2)     ,
1    (PARAM(58),YHS1)     , (PARAM(59),YHS2)    , (PARAM(60),AKD)      ,
1    (PARAM(61),TQDBR)    , (PARAM(62),AK)      , (PARAM(63),PIN)      ,
1    (PARAM(64),QIN)      , (PARAM(65),RIN)     , (PARAM(66),UIZ)      ,
1    (PARAM(67),VIN)      , (PARAM(68),WIN)     , (PARAM(69),XIN)      ,
1    (PARAM(70),YIN)      , (PARAM(71),ZIN)     , (PARAM(72),THETIN)   ,
1    (PARAM(73),PHIIN)    , (PARAM(74),PSIIN)   , (PARAM(75),DTIN)     ,
1    (PARAM(76),TEND)     , (PARAM(77),AKT1)    , (PARAM(78),AKT2)     ,
1    (PARAM(79),AKT3)     , (PARAM(80),AKT4)    , (PARAM(81),RPS1)     ,
1    (PARAM(82),RPS2)     , (PARAM(83),RPS3)    , (PARAM(84),RPS4)     ,
1    (PARAM(85),B1)       , (PARAM(86),B2)      , (PARAM(87),B3)
 EQUIVALENCE
1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),
1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),
1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),
1    (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),
1    (PARAM(106),S4PIN), (PARAM(107),PPRT)
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)
1   ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)
1   ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)
1    ,(PARAM(124),TSW)
 EQUIVALENCE
   (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),
1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),
1  (PARAM(136),CCR),(PARAM(137),CFCP),(PARAM(138),AP),
1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),
1  (PARAM(142),ERR2),
1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RRIM),
1    (PARAM(146),RWR),
1     (PARAM(196),EPSK1),(PARAM(197),EPSK2)
 EQUIVALENCE
1    (PARAM(284),HFC),(PARAM(285),HRC)
 EQUIVALENCE
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
 EQUIVALENCE
1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),
1(PARAM(302),PHIRD),(PARAM(303),PHIF),(PARAM(304),DELFW1),
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),
1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),
1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),
1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),
1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))
 EQUIVALENCE (NAME(172),NAMEX(1))
 EQUIVALENCE (PHIRD,DEL4DT),(PHIF,DEL4)
 DATA NAME/'  MS','  MUF',' NUR','  ZF','  ZR','   A','   B','  TF',
1    '  TR','  TS','  IX','  IY','  IZ',' IXZ','  IP','  CF','  FF',
1    'CFPR','  KF','LAMF','OMFC','OMFT','  CR','  RR','CRPR','  KR',
1    'LAMR','OMRC','OMRT',' KRS','  RW','    ',' ROT','  A0','  A1',
1    '  A2','  A3','  A4','    ','    ',' KSC','  NG','LAFC','LAFT',
1    'LARC','LART',' IFW','    ',' IRF',' IWR','  ID','  AR','    ',
1    '    ','  FT','YSA1','YSA2','PHS1','PHS2','CTSW','    ','    ',
1    'P-IN','Q-IN','R-IN','U-IN','V-IN','W-IN','X-IN','Y-IN','Z-IN',
```

```
     1   'THIN','PHIN','PSIN','  DT','  TN',' KT1',' KT2',' KT3',' KT4',SBPG1200
     1   'RPS1','RPS2','RPS3','RPS4','  B1','  B2','  B3','  B4','D1DT',SBPG1210
     1   'D2DT','D3DT','DELF','DELR','DEL3','PHDT','PHIR','DFW1','DFW2',SBPG1220
     1   'U1PR','U2PR','U3PR','U4PR','S1PR','S2PR','S3PR','S4PR','PPRT',SBPG1230
     1   '    ','    ','TQMX',' KTQ','  VC','MTSW','DSWM',' TST','DSLP',SBPG1240
     1   'CGAM','  CS','    ','    ',' PFL','  T1',' DSW',' TSW','ISW5',SBPG1250
     1   'SW15',                                                        SBPG1260
     1   'PQSW','VTPS','VHTP','AMCR',' ESP','KSL1','KSL2',' AA1',' AA2',SBPG1270
     1   ' CCR','CFCP','  AP',' EP1',' EP2','ERR1','ERR2','AML1','AML2',SBPG1280
     1   'RRIM','    ','    ','    ','    ','    ','    ','    ','    ',SBPG1290
     1   '    ','    ','    ','    ','    ','    ','    ','    ','    ',SBPG1300
     1   '    ','    ','    ','    ','    ','    ',' SNT','SNS0','SNS1'/SBPG1310
      DATA NAMEX                                                        SBPG1320
     1  /'SNSW','DIST',' PL ','TSCP','    ','    ','    ','    ','PAST',SBPG1330
     1   '    ',' SI1',' SI2',' SI3',' SI4','    ','    ','    ','    ', SBPG1340
     1   '    ','    ','    ','MTQB','DRSW',' LDF','LDRF',' EK1',' EK2',SBPG1350
     1   'BMPL','BMPS','BMPH','  XB','APF1','APF2','APR1','APR2','MUSF',SBPG1360
     1   'MUSR','    ','    ','    ','    ','    ','    ','    ','    ',SBPG1370
     1   '    ','    ','    ','FEE1','FEE2','THE1','THE2','    ','    ',SBPG1380
     1   '    ','    ','    ','    ','    ','    ','  H1','  H2','    ',SBPG1390
     1   'AKF1','AKF2','AKF3','AKF4',' BR1',' BR2',' BR3',' BR4',       SBPG1400
     1   ' KCF',' KCR',' KSR',' PB1',' PB2',' PB3',' PB4','AFK1','AFK2',SBPG1410
     1   'AFK3','ARK1','ARK2','ARK3','OFC0','OFC1','OFC2','OFC3','ORC0',SBPG1420
     1   'ORC1','ORC2','ORC3','CP0F','CP1F','CP2F','CP0R','CP1R','CP2R',SBPG1430
     1   'CR0F','CR1F','CR2F','CR0R','CR1R','CR2R','    ','    ','BMPV',SBPG1440
     1   'TQB0','TQB1','    ','    ','    ','    ',' HFC',' HRC','    ',SBPG1450
     1   'AXLE','    ','    ','ROT','RA0','RA1','RA2','RA3','RA4'/     SBPG1460
      EQUIVALENCE (COMPVR(1),AXAVE)                                     SBPG1470
      DIMENSION COMPVR(17)                                              SBPG1480
      DATA RAD/0.1745329E-1/                                            SBPG1490
      REAL*4 IOUT(48),IN,ITMP,SCALAC(28),SCALDC(48)                     SBPG1500
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,CPEN  ,OPDN                      SBPG1510
  960 FORMAT('1  PARAMETER VALUES - MODEL C - ',20A4,/                  SBPG1520
     1   ('  ',5(I4,3X,A4,'=',G12.5,',')))                              SBPG1530
C     VHTP COMPARISON VARIABLE INITIALIZATION                           SBPG1540
      DO 21 I=1,19                                                      SBPG1550
      COMPVR(I) = 0.                                                    SBPG1560
   21 CONTINUE                                                          SBPG1570
      TSTEP = DTIN                                                      SBPG1580
      NUMBR = 0                                                         SBPG1590
      DO 20 I=1,4                                                       SBPG1600
      DELX(I) = 0.                                                      SBPG1610
   20 CONTINUE                                                          SBPG1620
      IVHTP = PARAM(129) + .5                                           SBPG1630
      TQFMAX=-1.E20                                                     SBPG1640
      TQRMAX=-1.E20                                                     SBPG1650
      AP1=PARAM(055)                                                    SBPG1660
      AP2=PARAM(213)                                                    SBPG1670
      AP3=PARAM(214)                                                    SBPG1680
      AP4=PARAM(215)                                                    SBPG1690
      AP5=PARAM(216)                                                    SBPG1700
      BTC1=PARAM(217)                                                   SBPG1710
      BTVMAX=-1.E20                                                     SBPG1720
      BTC2=PARAM(218)                                                   SBPG1730
      FEE1=PARAM(219)*.01745329                                         SBPG1740
      FEE2=PARAM(220)*.01745329                                         SBPG1750
      PSIMAX=-1.E20                                                     SBPG1760
      THE1=PARAM(221)*.01745329                                         SBPG1770
      THE2=PARAM(222)*.01745329                                         SBPG1780
      PSIM=PSIIN*RAD                                                    SBPG1790
```

```
      XEND=TEND
         EXIT2  = 10.0*5280.0*12.0/3600.0
      TIME25=0.0
      TIME10=0.0
      O1=-6.0E-6
      O2=0.009
      O3=0.0001
      E4=-0.16
      E5=-0.46
      E6=10.4
      ANUMO=0.0
      ADENO=0.0
      RMAX=-1.E20
      PSI5=0.0
      DSWMAX=-1.E20
      PHIMAX=-1.E20
      ETAMAX=-1.E20
      DEL1DT=DEL1DN
      DEL2DT=DEL2DN
      DEL3DT=DEL3DN
      DEL1=0.0
      DEL2=0.0
      DEL3=DEL3IN
      PHIRD=PHIDN*RAD
      PHIR=PHIRN*RAD
      DELFW1=DFW1IN*RAD
      DELFW2=DFW2IN*RAD
      U1P=U1PIN
      U2P=U2PIN
      U3P=U3PIN
      U4P=U4PIN
      S1P=S1PIN
      S2P=S2PIN
      S3P=S3PIN
      S4P=S4PIN
      QUAN1=0.0
      QUAN2=0.0
      QUAN3=0.0
      QUAN4=0.0
      F1F1=CFP*SIGN(1.,DEL1DT)
      F1F2=CFP*SIGN(1.,DEL2DT)
      IF(DEL1.LT.OFC) GO TO 1
      IF(DEL1.GT.OFT) GO TO 2
      F2F1=AKF*DEL1
      GO TO 3
    1 F2F1=AKF*(ALAMF*DEL1-(ALAMF-1.)*OFC)
      GO TO 3
    2 F2F1=AKF*(ALAMF*DEL1-(ALAMF-1.)*OFT)
    3 IF(DEL2.LT.OFC) GO TO 4
      IF(DEL2.GT.OFT) GO TO 5
      F2F2=AKF*DEL2
      GO TO 6
    4 F2F2=AKF*(ALAMF*DEL2-(ALAMF-1.0)*OFC)
      GO TO 6
    5 F2F2=AKF*(ALAMF*DEL2-(ALAMF-1.)*OFT)
    6 S1P=-CF*DEL1DT-F1F1-F2F1+(RF*(DEL2-DEL1))/TF**2
      S2P=-CF*DEL2DT-F1F2-F2F2-(RF*(DEL2-DEL1))/TF**2
      IF( PARAM(287).EQ.2. ) GO TO 106
      ZETA3=TS*PHIR/2.+DEL3
      ZETA3D=TS*PHIRD/2.+DEL3DT
```

```
      ZETA4=-ZETA3+2.*DEL3
      ZETA4D=-ZETA3D+2.*DEL3DT
      GO TO 15
  106 ZETA3=DEL3
      ZETA4=DEL4
      ZETA3D=DEL3DT
      ZETA4D=DEL4DT
   15 CONTINUE
      IF(ZETA3.LT.OBC)GO TO 7
      IF(ZETA3.GT.OBT)GO TO 8
      F2R3=AKR*ZETA3
      GO TO 9
    7 F2R3=AKR*(ALAMR*ZETA3-(ALAMR-1.)*OBC)
      GO TO 9
    8 F2R3=AKR*(ALAMR*ZETA3-(ALAMR-1.)*OBT)
    9 IF(ZETA4.LT.OBC)GO TO 10
      IF(ZETA4.GT.OBT)GO TO 11
      F2R4=AKR*ZETA4
      GO TO 12
   10 F2R4=AKR*(ALAMR*ZETA4-(ALAMR-1.)*OBC)
      GO TO 12
   11 F2R4=AKR*(ALAMR*ZETA4-(ALAMR-1.)*OBT)
   12 F1R3=CRP*SIGN(1.,ZETA3D)
      F1R4=CRP*SIGN(1.,ZETA4D)
      IF(PARAM(287).EQ.2.) GO TO 13
      S3P=-CR*ZETA3D-F1R3-F2R3-RR*PHIR/TS
      S4P=-CR*ZETA4D-F1R4-F2R4+RR*PHIR/TS
      GO TO 14
   13 S3P=-CR*ZETA3D-F1R3-F2R3+(RR/TR**2)*(DEL4-DEL3)
      S4P=-CR*ZETA4D-F1R4-F2R4-(RR/TR**2)*(DEL4-DEL3)
   14 CONTINUE
      P=PIN*RAD
      PO=P
      Q=QIN*RAD
      QO=Q
      R=RIN*RAD
      RO=R
      U=UIN
      UO=U
      V=VIN
      VO=VIN
      W=WIN
      WO=WIN
      X=XIN
      XO=XIN
      Y=YIN
      YO=YIN
      Z=ZIN
      ZO=ZIN
      THE=THEIN*RAD
      THEO=THE
      PHI=PHIIN*RAD
      PHIO=PHI
      PSI=PSIIN*RAD
      PSIO=PSI
      IF(PPRT.NE.0.0) WRITE(LPTR,960) (ALPH(I),I=1,20),((K,NAMP(K),
     1 PARAM(K)),K=1,N1)
  940 FORMAT(10G12.5)
      TIME=0.0
      JJTIME=0
```

```
      DT=0.0                                                            SBPG3000
  998 FORMAT('0',8E15.6)                                                SBPG3010
      IHSW=0                                                            SBPG3020
      XB(1)=PARAM(201)                                                  SBPG3030
      NBMP=PARAM(277)+0.5                                               SBPG3040
      IF(NBMP.LT.2) GO TO 4321                                          SBPG3050
      DO 5432 I=2,NBMP                                                  SBPG3060
      XB(I)=XB(I-1)+PARAM(199)                                          SBPG3070
 5432 CONTINUE                                                          SBPG3080
 4321 CONTINUE                                                          SBPG3090
      CALL SBPG22                                                       SBPG3100
      CALL LBDAFP(00,47,DACO,ILPERR)                                    SBPG3110
      CALL TLDA                                                         SBPG3120
      DO 6240 I=1,48                                                    SBPG3130
      ITMP(I) = DACO(I)                                                 SBPG3140
 6240 CONTINUE                                                          SBPG3150
      CALL STCO(1,ISTCOE)                                               SBPG3160
      DT=DTIN                                                           SBPG3170
      ISW1=0                                                            SBPG3180
      ISW7=0                                                            SBPG3190
      RETURN                                                            SBPG3200
      END                                                               SBPG3210
```

2.1.3 POTSET

PRESENTED HERE IS THE FORTRAN LISTING FOR THE POTENTIOMETER SETTING CALCULATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN POTSET:

1) Calculation of parameters used in the potentiometer equations.

2) Calculation of potentiometer settings.

3) Calculation of analog-to-digital converter scale factors.

```
C     SUBROUTINE POTSET
      SUBROUTINE POTSET
C     THIS SUBROUTINE CALCULATES VALUES FOR POTENTIOMETER SETTINGS
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
      COMMON/HHHH/H1,H2,H3,H4
      COMMON/SPLTAX/SPSR3,CPSR3,SPSR4,CPSR4,SCR3,SCR4,TBCR3,TBCR4,TBSR3,
     1   TBSR4,TRSR3,TRSR4,TRCR3,TRCR4,PSR3,PSR4,IAX
      COMMON/CLEAN/ONEOA,ONEOD
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1     YO,ZO,THEO,PHIO,PSIO
      COMMON/ZILCH/TQMAXP,AKTQP
      COMMON/INOUT/INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,SFIN(32),
     1      SFOUT(48),IPRT,ITMP(48)
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1     AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1     GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,            ANGNL,ANGNLO
     1     ,TRO2,TFO2,TSO2,G,THRD,TWN7
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/UVW/VC,UIN
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      EQUIVALENCE
     1    (PARAM( 1),AMS)      , (PARAM( 2),AMUF)    , (PARAM( 3),AMUR)    ,
     1    (PARAM( 4),ZF)       , (PARAM( 5),ZR)      , (PARAM( 6),A)       ,
     1    (PARAM( 7),B)        , (PARAM( 8),TF)      , (PARAM( 9),TR)      ,
     1    (PARAM(10),TS)       , (PARAM(11),AIX)     , (PARAM(12),AIY)     ,
     1    (PARAM(13),AIZ)      , (PARAM(14),AIXZ)    , (PARAM(15),AIE)     ,
     1    (PARAM(16),CF)       , (PARAM(17),RF)      , (PARAM(18),CFP)     ,
     1    (PARAM(19),AKF)      , (PARAM(20),ALAMF)   , (PARAM(21),OFC)     ,
     1    (PARAM(22),OFT)      , (PARAM(23),CR)      , (PARAM(24),RR)      ,
     1    (PARAM(25),CRP)      , (PARAM(26),AKR)     , (PARAM(27),ALAMR)   ,
     1    (PARAM(28),ORC)      , (PARAM(29),ORT)     , (PARAM(30),AKFS)    ,
     1    (PARAM(31),RW)                             , (PARAM(33),OT)      ,
     1    (PARAM(34),CA0)      , (PARAM(35),CA1)     , (PARAM(36),CA2)     ,
     1    (PARAM(37),CA3)      , (PARAM(38),CA4)     , (PARAM(39),AISW)    ,
     1    (PARAM(44),AKDL)     , (PARAM(41),AKSC)    , (PARAM(42),ANG)     ,
     1    (PARAM(43),WG)       , (PARAM(40),ANL2)    , (PARAM(45),AKSL)
      EQUIVALENCE
     1    (PARAM(46),ANL1)     , (PARAM(47),AIFW)    , (PARAM(48),HDL)     ,
     1    (PARAM(49),AIWF)     , (PARAM(50),AIWR)    , (PARAM(51),AID)     ,
     1    (PARAM(52),ARBR)     , (PARAM(53),EPS1)    , (PARAM(54),EPS2)    ,
     1    (PARAM(55),PTBR)     , (PARAM(56),YSA1)    , (PARAM(57),YSA2)    ,
     1    (PARAM(58),YHS1)     , (PARAM(59),YHS2)    , (PARAM(60),AKD)     ,
     1    (PARAM(61),TQDBR)    , (PARAM(62),AF)      , (PARAM(63),PIN)     ,
     1    (PARAM(64),QIN)      , (PARAM(65),RIN)     , (PARAM(66),UIN)     ,
     1    (PARAM(67),VIN)      , (PARAM(68),WIN)     , (PARAM(69),XIN)     ,
     1    (PARAM(70),YIN)      , (PARAM(71),ZIN)     , (PARAM(72),THEIN)   ,
     1    (PARAM(73),PHIIN)    , (PARAM(74),PSIIN)   , (PARAM(75),DTIN)    ,
     1    (PARAM(76),TEND)     , (PARAM(77),AKT1)    , (PARAM(78),AKT2)   ,
     1    (PARAM(79),AKT3)     , (PARAM(80),AKT4)    , (PARAM(81),RPS1)   ,
     1    (PARAM(82),RPS2)     , (PARAM(83),RPS3)    , (PARAM(84),RPS4)    ,
     1    (PARAM(85),B1)       , (PARAM(86),B2)      , (PARAM(87),B3)
      EQUIVALENCE
     1 (PARAM(88),B4),         (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
     1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
     1   (PARAM( 94),DEL3TN), (PARAM( 95),PHIDN), (PARAM(96),PHIPN),
     1   (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),
     1   (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),
```

```
      1    (PARAM(103),S1PIN),   (PARAM(104),S2PIN), (PARAM(105),S3PIN),
      1    (PARAM(106),S4PIN),  (PARAM(107),PPRT)
      1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)
      1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),
      1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)
      1   ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)
      1   ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)
      1     ,(PARAM(124),TSW)
       EQUIVALENCE
      1   (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),
      1   (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),
      1   (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),
      1   (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),
      1   (PARAM(142),ERR2),
      1   (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RPIM),
      1    (PARAM(146),RWR)
      1    ,(PARAM(196),EPSK1),(PARAM(197),EPSK2)
       EQUIVALENCE
      1    (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),
      1    (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),
      1    (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),
      1    (PARAM(232),AH2),(PARAM(233),ANL),(PARAM(234),AKF1),
      1   (PARAM(235),AKF2),(PARAM(236),AKR3),(PARAM(237),AKR4)
       EQUIVALENCE
      1    (PARAM(284),HFC),(PARAM(285),HRC)
       EQUIVALENCE
      1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
      1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
       EQUIVALENCE
      1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),
      1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),
      1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),
      1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),
      1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),
      1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),
      1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),
      1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),
      1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),
      1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))
       REAL*4 IOUT(48)
       DATA                   T/10000.0/
C      N1 , N2 EQUATED TO THEIR VALUES IN MAIN
       IAX=PARAM(287)+0.5
       PSR3=PARAM(288)*.0174533
       PSR4=PARAM(289)*.0174533
       SPSR3=(TAN(2.0*HFC/TF))*2.0/AMUF
       SPSR4=(TAN(2.0*HRC/TR))*2.0/AMUF
       CPSR3=COS(PSR3)
       CPSR4=COS(PSR4)
       SCR3=SPSR3*CPSR3
       SCR4=SPSR4*CPSR4
       TMP=2.0*B/TS
       TBSR3=TMP*SPSR3
       TBSR4=TMP*SPSR4
       TBCR3=TMP*CPSR3
       TBCR4=TMP*CPSR4
       TMP=TR/TS
       TRSR3=TMP*SPSR3
       TRSR4=TMP*SPSR4
       TRCR3=TMP*CPSR3
```

```
      TRCR4=TMP*CPSR4
      SM=AMS+AMUF+AMUR
      UIN=UIZ*12.0*5280.0/3600.0
      VC=VCIN*12.0*5280.0/3600.0
      ISW7=1
      IPRT=PARAM(108)+0.5
      TWO3=2.0/3.0
      HUN=0.01
      TOU=0.001
      TTO=0.0001
      G=386.4
      THRD=1.0/3.0
      TWN7=1.0/27.0
      H1=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT1)
      H2=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT2)
      H3=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT3)
      H4=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT4)
      ZIN=(B*(H1+ZF)+A*(H3+ZR))/(A+B)*(-1.)
      THEIN=(H1-H3+ZF-ZR)/(A+B)*57.29578
      AIBR=AIWR+AID*ARBR**2*0.25
      AIBRP=AIBR-AIWR
      TOO=0.0
      RPS1=UIN/H1
      RPS2=UIN/H2
      RPS3=UIN/H3
      RPS4=UIN/H4
      TFO2=TF*0.5
      TSO2=TS/2.0
      TRO2=TR*0.5
      AIXP=AMUF*ZF*ZF+AMUR*ZR*ZR
      AIYP=AIXP
      AIZP=AMUF*(A*A+TFO2**2)+AMUR*B*B + AIR
      IF(IAX.EQ.1) GO TO 30
      AIZP=AIZP+AMUR*TRO2**2 - AIR
   30 AIXZP=AMUF*A*ZF-AMUR*B*ZR
      GAM1=AMUF*A-AMUR*B
      GAM2=AMUF*ZF+AMUR*ZR
      GAM3=GAM2
      AIXBR=AIX+AIXP
      AIYBR=AIY+AIYP
      AIZBR=AIZP +AIZ
      A1=GAM2/SM
      A2=AIYBR/GAM2
      AIXZBR=AIXZP+AIXZ
      CA23=CA2*CA3
      A12=A1-A2
      E1=AIXBR*AIZBR-AIXZBR**2
      E2=GAM1*AIXZBR-GAM3*AIZBR
      E3=GAM3*AIXZBR-GAM1*AIXBR
      DELTA=E1*SM+GAM2*E2+GAM1*E3
      GV1=GAM2*AIZBR-GAM1*AIXZBR
      GV2=GAM2*AIXZBR-GAM1*AIXBR
      GP1=SM*AIZBR-GAM1**2
      GP2=SM*AIXZBR-GAM1*GAM3
      GR1=GP2
      GR2=SM*AIXBR-GAM2*GAM3
      CIP=B*AMS*G/(AMUF*(A+B))+G
      TQMAXP=TQMAX*ARBR*0.5
      AKTQP=AKTQ*ARBR*0.5
      CIVP=A*AMS*G/(AMUR*(A+B))+G
```

```
      PZF=RW+ZF                                                         POTS1800
      RZR=RW+ZR                                                         POTS1810
      A2T= OT*CA2                                                       POTS1820
      CA20=CA0*CA2                                                      POTS1830
      ONEOA=1.0/A12                                                     POTS1840
      ONEOD=1.0/DELTA                                                   POTS1850
      IPOT(01 )=T*PARAM(175)/AMS                                        POTS1860
      IPOT(02 )=(2.0/(10.0*AMUF))*T*PARAM(175)                          POTS1870
      IPOT(04 )=(HUN*RF/(TF*TF))*T*0.1                                  POTS1880
      IPOT(03 )=IPOT(04 )                                               POTS1890
      IPOT(05)=(2.0*AKT2/(5000.0*AMUF))*T/1.0*PARAM(175)                POTS1900
      IPOT(06 )=T*PARAM(175)/AMS                                        POTS1910
      IPOT(07 )=IPOT(02 )                                               POTS1920
      IPOT(14)=RF/(TF*TF*100.0)*T*0.1                                   POTS1930
      IPOT(10 )=(AKT3/(5000.0*AMUR))*T*PARAM(175)                       POTS1940
      IPOT(11 )=(AKT4/(5000.0*AMUR))*T*PARAM(175)                       POTS1950
      IPOT(12 )=T*PARAM(175)/AMS                                        POTS1960
      IPOT(13 )=(0.1/AMUR)*T*PARAM(175)                                 POTS1970
      IPOT(09 )=IPOT(13 )                                               POTS1980
      IPOT(08)=RF/(TF*TF*100.0)*T *0.1                                  POTS1990
      IPOT(16 )=TOU*CFP*T                                               POTS2000
      IPOT(19 )=.1*TOU*2.0*CFP*T                                        POTS2010
      IPOT(21)=PARAM(175)*T                                             POTS2020
      IPOT(22 )=IPOT(16 )                                               POTS2030
      IPOT(24 )=IPOT(19 )                                               POTS2040
      IPOT(25)=PARAM(175)*T                                             POTS2050
      IPOT(27 )=TOU*CRP*T                                               POTS2060
      IPOT(28)=PARAM(175)*T                                             POTS2070
      IPOT(29 )=.1*TOU*2.0*CRP*T                                        POTS2080
      IPOT(31)=PARAM(175)*T                                             POTS2090
      IPOT(32)=(2.0*AKT1/(5000.0*AMUF))*T/1.0*PARAM(175)                POTS2100
      IPOT(33)=PARAM(175)*T                                             POTS2110
      IPOT(49 )=IPOT(27 )                                               POTS2120
      IPOT(51 )=(60.0*AKT1/(10000.0*AIWF))*T*PARAM(175)                 POTS2130
      IPOT(52 )=(4.0/AIWF)*T*PARAM(238)*PARAM(175)                      POTS2140
      IPOT(54 )=IPOT(29 )                                               POTS2150
      IPOT(60)  =(AKF/1000.)*T                                          POTS2160
      IPOT(61)  =(AKF/1000.)*T                                          POTS2170
      IPOT(62)  =(AKF/1000.)*T                                          POTS2180
      IPOT(63)  =(AKF/1000.)*T                                          POTS2190
      IPOT(83 )=(60.0*AKT4/(10000.0*AIBR))*T*PARAM(175)                 POTS2200
      IPOT(086)=0.2000*T                                                POTS2210
      IPOT(87 )=0.1333*T                                                POTS2220
      IPOT(88 )=(RW/15.0)*T                                             POTS2230
      IPOT(92)=57.3/200.*T*PARAM(175)                                   POTS2240
      IPOT(096)=0.2000*T                                                POTS2250
      IPOT(97)=IPOT(92)                                                 POTS2260
      IPOT(98 )=IPOT(88 )                                               POTS2270
      IPOT(99 )=IPOT(87 )                                               POTS2280
      IPOT(100)=2.*IPOT(92)                                             POTS2290
      IPOT(101)=HUN*RPS1*T                                              POTS2300
      IPOT(102)=(60.0*AKT2/(10000.0*AIWF))*T*PARAM(175)                 POTS2310
      IPOT(103)=(4.0/AIWF)*T*PARAM(239)*PARAM(175)                      POTS2320
      IPOT(104)=HUN*RPS2*T                                              POTS2330
      IPOT(105)=2.*IPOT(97)                                             POTS2340
      IPOT(106)=0.2*T                                                   POTS2350
      IPOT(107)=IPOT(87 )                                               POTS2360
      IPOT(108)=IPOT(88 )                                               POTS2370
      IPOT(110)=HUN*RPS3*T                                              POTS2380
      IPOT(111)=(4.0/AIBR)*T*PARAM(241)*PARAM(175)                      POTS2390
```

```
      IPOT(112)=(4.0/AIBR)*T*PARAM(240)*PARAM(175)
      IPOT(113)=(60.0*AKT3/(10000.0*AIBR))*T*PARAM(175)
      IPOT(114)=HUN*RPS4*T
      IPOT(116)=IPOT(106)
      IPOT(117)=IPOT(87 )
      IPOT(118)=IPOT(88 )
      IPOT(119)=AIBRP/AIBR*T*PARAM(175)
      IPOT(50 )=IPOT(119)
      CALL SSRP(08,IRLERR)
      IF(RR.GE.0) GO TO 1023
      CALL SSRM(08,IRLERR)
 1023 CONTINUE
      IF(IAX.EQ.2)GO TO 1021
C############################################
C#####     SOLID AXLE LOGIC FOR 680     #####
C############################################
            CALL SSRP(00,IRLERR)
            CALL SSRP(01,IRLERR)
            CALL SSRP(02,IRLERR)
            CALL SSRP(03,IRLERR)
            CALL SSRP(07,IRLERR)
            CALL SSRP(10,IRLERR)
            CALL RSCL( 01,IRSCLE )
      IPOT(15 )=(10.0*TS/AIR)*T*PARAM(175)
      IPOT(17 )=0.40*T*PARAM(175)
      IPOT(26)=(ABS(RR)/(4000.*TS))*T*0.1
      IPOT(36 )=(TSO2/40.0)*T
      IPOT(40)=0
      IPOT(41)=0
      IPOT(42 )=0
      IPOT(45 )=IPOT(36 )
      IPOT(46 )=(HUN*TSO2*T)
      IPOT(35 )=IPOT(46 )
      IPOT(53 )=IPOT(26 )
      IPOT(71)  =0
      IPOT(80 )=0
      IPOT(81 )=0
      IPOT(82 )=0
      IPOT(109)=(TRO2/40.0)*T
      IPOT(115)=IPOT(109)
      GO TO 1022
 1021 CONTINUE
C############################################
C####     SPLIT AXLE LOGIC FOR 680     #####
C############################################
            CALL SSRM(00,IRLERR)
            CALL SSRM(01,IRLERR)
            CALL SSRM(02,IRLERR)
            CALL SSRM(03,IRLERR)
            CALL SSRM(07,IRLERR)
            CALL SSRM(10,IRLERR)
            CALL SSCL( 01,ISSCLE )
      IPOT(41)=2.0/(10.0*AMUR)*T*PARAM(175)
      IPOT(40)=AKT3*2.0/(5000.0*AMUR)*T*PARAM(175)
      IPOT(42 )=T*PARAM(175)/AMS
      IPOT(71)  =(RR/(100.*TR**2))*T
      IPOT(80 )=AKT4*2.0/(5000.0*AMUR)*T*PARAM(175)
      IPOT(81 )=2.0/(10.0*AMUR)*T*PARAM(175)
      IPOT(82 )=T*PARAM(175)/AMS
      IPOT(36 )=0
```

```
      IPOT(46 )=0
      IPOT(109)=0
      IPOT(115)=0
      IPOT(45 )=0
      IPOT(35 )=0
      IPOT(26 )=0
      IPOT(53 )=0
      IPOT(17 )=0
      IPOT(15 )=0
 1022 CONTINUE
               CALL SSRM(11,IRLERR)
      IPOT(55)=.5000*T
      IPOT(56)=.5000*T
      IPOT(58)=.5000*T
      IPOT(72)=.5000*T
      SFIN(1)=-100.0
      SFIN(2)=SFIN(1)
      SFIN(3)=SFIN(1)
      SFIN(4)=10.0
      SFIN(5)=SFIN(4)
      SFIN(6)=SFIN(4)
      SFIN(7)=1.0
      SFIN(8)=0.25
      IF(IAX.EQ.2)SFIN(7)=SFIN(1)
      IF(IAX.EQ.2)SFIN(8)=SFIN(4)
      SFIN(9)=0.5
      SFIN(10)=SFIN(9)
      SFIN(11)=2.0
      SFIN(12)=SFIN(11)
      SFIN(13)=SFIN(11)
      SFIN(14)=SFIN(11)
      SFIN(15)=1000.0
      SFIN(16)=SFIN(15)
      SFIN(17)=SFIN(15)
      SFIN(18)=SFIN(15)
      SFIN(19)=1.0
      SFIN(20)=1.0
      SFIN(21)=1.0
      SFIN(22)=1.0
      SFIN(23)=100.
      SFIN(24)=100.
      SFIN(25)=1.0
      SFIN(26)=1.0
      SFIN(27)=1.0
      SFIN(28)=1.0
      IN(23)=RPS1+SIGN(0.5,RPS1)
      IN(24)=RPS2+SIGN(0.5,RPS2)
      IN(25)=0
      IN(26)=1
      IN(27)=0
      IN(28)=1
      DO 10 I=1,48
      SFOUT(I)=1.0
   10 CONTINUE
      SFOUT(9)=1.0/10000.
      SFOUT(10)=0.1
      SFOUT(14)=1.0/10000.
      SFOUT(25)=0.01*  AKT3/AIR
      SFOUT(27)=0.01*  AKT4/AIR
      SFOUT(28)=0.01
```

```
      SFOUT(37)=(1.0/1500.0)                                            POTS3600
      RETURN                                                            POTS3610
      END                                                               POTS3620
```

2.1.4 SBPG2

PRESENTED HERE IS THE FORTRAN LISTING FOR THE MATHEMATICAL MODEL SUBPROGRAM. THE FOLLOWING IS PERFORMED IN SBPG2:

1) Reading of the analog-to-digital converter variables.

2) Computation of simulation time.

3) Calculation of all digital model equations.

4) Data preparation for output on the digital-to-analog (D/A) converters.

5) Detection, limiting, and flagging of D/A variable overloads.

6) Collection of TRACK data for output at the end of a run.

```
C     SUBROUTINE SBPG2
      SUBROUTINE SBPG2
      COMMON/START/ ZDUMMY(4)
      COMMON/FMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20),IOP
      COMMON/IO/DACPLA,ADCPLA,SCALDC,SCALAC
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
     1 ITRAA,ITRNA,ITRIA
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                     FXL1,FXL2,THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBT(4),FRIBR(4),
     1        RWZI(4),ZI(4),FRI(4),          UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
      COMMON/HHHH/H1,H2,H3,H4
      COMMON/SPLTAX/SPSR3,CPSR3,SPSR4,CPSR4,SCR3,SCR4,TBCR3,TBCR4,TBSR3,
     1   TBSR4,TRSR3,TRSR4,TRCR3,TRCR4,PSR3,PSR4,IAX
      COMMON/SOLDAX/DELPHI(20),PHIFNT(20),DELTHE(20),THEFNT(20),NCAM,
     1 NCAS,PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
      COMMON/OUTVAR/VOUT,BTV,PSI3S,PSI4S
      COMMON/EXTRA/           UOUT,ROUT,        PSIOUT,EXTAB(002),
     1   DLYTB(002),HTAB(002)
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/FEES/FEE1,FEE2,THE1,THE2
      COMMON/DELS/DELSWC
      COMMON/CLEAN/ONEOA,ONFOD
      COMMON/XYZ/NUMBR
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/XBS/XB(15),NS(4,15),DELX(4),XI(4),NNN
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/UVW/VC,UIN
      COMMON/EES/E1,E2,E3,E4,E5,E6
      COMMON/ZILCH/TQMAXP,AKTQP
      COMMON/INOUT/ INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,
     1SFIN(32),SFOUT(48),IPRT,ITMP(48)
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,               ANGNL,ANGNLO
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/OPSW/IHSW
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWEP/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/MICKEY/IRUNTB(002),VTB(002),SNLTB(002),SNRTB(002),DSWTB(002
     1 ),RTTB(002),DTB(002),EFFTB(002),DYTB(002),PSITB (002),NRUN,
     1   YSPEC,PSIM,XPF
      COMMON/NONAME/XEND,O,EXIT2
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```
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTRP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMINS,         TSTEP ,    IVETP
      DIMENSION CSI(4),XRM(4),SLP(4)
      REAL*8 ZDUMMY
      EQUIVALENCE (EVALUE(1),ZDUMMY(1))
      EQUIVALENCE  (APF(1),APF1),(APR(1),APR1),(MUS(1),MUSF),
     1             (APF(2),APF2),(APR(2),APR2),(MUS(2),MUSR)
      EQUIVALENCE
     1   (PARAM( 1),AMS)      , (PARAM( 2),AMUF)    , (PARAM( 3),AMUR)     ,
     1   (PARAM( 4),ZF)       , (PARAM( 5),ZR)      , (PARAM( 6),A)        ,
     1   (PARAM( 7),B)        , (PARAM( 8),TF)      , (PARAM( 9),TR)       ,
     1   (PARAM(10),TS)       , (PARAM(11),AIX)     , (PARAM(12),AIY)      ,
     1   (PARAM(13),AIZ)      , (PARAM(14),AIXZ)    , (PARAM(15),AIR)      ,
     1   (PARAM(16),CF)       , (PARAM(17),RF)      , (PARAM(18),CFP)      ,
     1   (PARAM(19),AKF)      , (PARAM(20),ALAMF)   , (PARAM(21),OFC)      ,
     1   (PARAM(25),CRP)      , (PARAM(26),AKR)     , (PARAM(27),ALAMR)    ,
     1   (PARAM(22),OFT)      , (PARAM(23),CR)      , (PARAM(24),RR)       ,
     1   (PARAM(28),ORC)      , (PARAM(29),ORT)     , (PARAM(30),AKRS)     ,
     1   (PARAM(31),RW)                             , (PARAM(33),OT)       ,
     1   (PARAM(34),CA0)      , (PARAM(35),CA1)     , (PARAM(36),CA2)      ,
     1   (PARAM(37),CA3)      , (PARAM(38),CA4)     , (PARAM(39),AISW)     ,
     1   (PARAM(44),LAFT)     , (PARAM(41),AKSC)    , (PARAM(42),ANG)      ,
     1   (PARAM(43),LAFC)     , (PARAM(40),ANL2)    , (PARAM(45),LARC)
      EQUIVALENCE
     1   (PARAM(46),LART)     , (PARAM(47),AIFW)    , (PARAM(48),HDL)      ,
     1   (PARAM(49),AIWF)     , (PARAM(50),AIWR)    , (PARAM(51),AID)      ,
     1   (PARAM(52),ARBP)     , (PARAM(53),EPS1)    , (PARAM(54),EPS2)     ,
     1   (PARAM(55),PTBR)     , (PARAM(56),YSA1)    , (PARAM(57),YSA2)     ,
     1   (PARAM(58),YHS1)     , (PARAM(59),YHS2)    , (PARAM(60),AKD)      ,
     1   (PARAM(61),TQDBR)    , (PARAM(62),AK)      , (PARAM(63),PIN)      ,
     1   (PARAM(64),QIN)      , (PARAM(65),RIN)     , (PARAM(66),UIZ)      ,
     1   (PARAM(67),VIN)      , (PARAM(68),WIN)     , (PARAM(69),XIN)      ,
     1   (PARAM(70),YIN)      , (PARAM(71),ZIN)     , (PARAM(72),THEIN)    ,
     1   (PARAM(73),PHIIN)    , (PARAM(74),PSIIN)   , (PARAM(75),DTIN)     ,
     1   (PARAM(76),TEND)     , (PARAM(77),AKT1)    , (PARAM(78),AKT2)    ,
     1   (PARAM(79),AKT3)     , (PARAM(80),AKT4)    , (PARAM(81),RPS1)    ,
     1   (PARAM(82),RPS2)     , (PARAM(83),RPS3)    , (PARAM(84),RPS4)     ,
     1   (PARAM(85),B1)       , (PARAM(86),B2)      , (PARAM(87),B3)
      EQUIVALENCE
     1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
     1   (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
     1   (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIDN) ,
     1   (PARAM( 97),DEW1IN), (PARAM( 98),DEW2IN),(PARAM( 99),U1PIN),
     1   (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),
     1   (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),
     1   (PARAM(106),S4PIN), (PARAM(107),PPBT)
     1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)
     1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),
     1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)
     1  ,(PARAM(119),TQRBF),(PARAM(120),TQRBR)
     1  ,(PARAM(121),BPL),(PARAM(122),TTD),(PARAM(123),DSW)
     1  ,(PARAM(124),TSW)
      EQUIVALENCE
     1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),
     1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),
     1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),
     1  (PARAM(139),ERP1),(PARAM(140),ERP2),(PARAM(141),ERF1),
     1  (PARAM(142),ERF2),
     1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RRIM),
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1    (PARAM(146),RWR),                                                  SBPG1200
1  (PARAM(169),SNT),(PARAM(170),SNSC),(PARAM(171),SNS1),                SBPG1210
1    (PARAM(182),SII(1)),(PARAM(196),EPSK1),(PARAM(197),EPSK2)          SBPG1220
 EQUIVALENCE (PARAM(202),APF(1)),(PARAM(204),APR(1)),                   SBPG1230
1    (PARAM(206),MUS(1))                                                SBPG1240
 EQUIVALENCE                                                            SBPG1250
1    (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),             SBPG1260
1    (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),             SBPG1270
1    (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),              SBPG1280
1    (PARAM(232),AH2),(PARAM(233),ANL),(PARAM(234),AKF1),               SBPG1290
1   (PARAM(235),AKF2),(PARAM(236),AKR3),(PARAM(237),AKR4),              SBPG1300
1  (PARAM(242),AKCF),(PARAM(243),AKCR),(PARAM(244),AKSR)                SBPG1310
 EQUIVALENCE (PARAM(245),RB(1)),(PARAM(249),TFK(1)),                    SBPG1320
1              (PARAM(252),TRK(1)),                                     SBPG1330
1              (PARAM(255),OFC0),(PARAM(256),OFC1),(PARAM(257),OFC2),SBPG1340
1              (PARAM(258),OFC3),(PARAM(262),ORC3),                     SBPG1350
1              (PARAM(259),ORC0),(PARAM(260),ORC1),(PARAM(261),ORC2)    SBPG1360
 EQUIVALENCE (PARAM(263),CP0F),(PARAM(264),CP1F),                       SBPG1370
1(PARAM(265),CP2F),(PARAM(266),CP0R),(PARAM(267),CP1R),                 SBPG1380
1(PARAM(268),CP2R),(PARAM(269),CR0F),(PARAM(270),CR1F),                 SBPG1390
1(PARAM(271),CR2F),(PARAM(272),CR0R),(PARAM(273),CR1R),                 SBPG1400
1(PARAM(274),CR2R)                                                      SBPG1410
 EQUIVALENCE (RB(1),RB1),(RB(2),RB2)                                    SBPG1420
 EQUIVALENCE (RB(3),RB3),(RB(4),RB4)                                    SBPG1430
 EQUIVALENCE (TFK(1),AFK1),(TRK(1),ARK1)                                SBPG1440
 EQUIVALENCE (TFK(2),AFK2),(TRK(2),ARK2)                                SBPG1450
 EQUIVALENCE (TFK(3),AFK3),(TRK(3),ARK3)                                SBPG1460
 EQUIVALENCE                                                            SBPG1470
1    (PARAM(284),HFC),(PARAM(285),HRC),                                 SBPG1480
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),                SBPG1490
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)                 SBPG1500
 EQUIVALENCE                                                            SBPG1510
1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),           SBPG1520
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),                 SBPG1530
1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),              SBPG1540
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),                 SBPG1550
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),                    SBPG1560
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),                    SBPG1570
1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),              SBPG1580
1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),              SBPG1590
1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),              SBPG1600
1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))                                SBPG1610
 EQUIVALENCE  (PHIRD,DEL4DT),(PHIR,DEL4)                                SBPG1620
 EQUIVALENCE (RWZI(1),RWZ1),(ZI(1),Z1),(FRI(1),FR1),(AKTI(1),AKT1),SBPG1630
1              (RWZI(2),RWZ2),(ZI(2),Z2),(FRI(2),FR2),(AKTI(2),AKT2),SBPG1640
1              (RWZI(3),RWZ3),(ZI(3),Z3),(FRI(3),FR3),(AKTI(3),AKT3),SBPG1650
1              (RWZI(4),RWZ4),(ZI(4),Z4),(FRI(4),FR4),(AKTI(4),AKT4),SBPG1660
1(UI(1),U1),(VI(1),V1),(WI(1),W1),(UGI(1),UG1),(VGI(1),VG1),            SBPG1670
1(UI(2),U2),(VI(2),V2),(WI(2),W2),(UGI(2),UG2),(VGI(2),VG2),            SBPG1680
1(UI(3),U3),(VI(3),V3),(WI(3),W3),(UGI(3),UG3),(VGI(3),VG3),            SBPG1690
1(UI(4),U4),(VI(4),V4),(WI(4),W4),(UGI(4),UG4),(VGI(4),VG4),            SBPG1700
1(SINPSI(1),SINPS1),(PSII(1),PSI1),(COSPSI(1),COSPS1),(UGIP(1),UG1PSBPG1710
1),(PHICGI(1),PHICG1),(CVI(1),CV1),(ABI(1),AB1),(BETAI(1),BETA1),       SBPG1720
1(SINPSI(2),SINPS2),(PSII(2),PSI2),(COSPSI(2),COSPS2),(UGIP(2),UG2PSBPG1730
1),(PHICGI(2),PHICG2),(CVI(2),CV2),(ABI(2),AB2),(BETAI(2),BETA2),       SBPG1740
1(SINPSI(3),SINPS3),(PSII(3),PSI3),(COSPSI(3),COSPS3),(UGIP(3),UG3PSBPG1750
1),(PHICGI(3),PHICG3),(CVI(3),CV3),(ABI(3),AB3),(BETAI(3),BETA3),       SBPG1760
1(SINPSI(4),SINPS4),(PSII(4),PSI4),(COSPSI(4),COSPS4),(UGIP(4),UG4PSBPG1770
1),(PHICGI(4),PHICG4),(CVI(4),CV4),(ABI(4),AB4),(BETAI(4),BETA4)        SBPG1780
 EQUIVALENCE (AMUI(1),AMU1),(SNI(1),SN1),(RMI(1),RM1),(GBI(1),GB1),SBPG1790
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     1              (AMUI(2),AMU2),(SNI(2),SN2),(RMI(2),RM2),(GBI(2),GB2),
     1              (AMUI(3),AMU3),(SNI(3),SN3),(RMI(3),RM3),(GBI(3),GB3),
     1              (AMUI(4),AMU4),(SNI(4),SN4),(RMI(4),RM4),(GBI(4),GB4),
     1(FRIBR(1),FR1BR),(ALFI(1),ALF1),(BETIP(1),BET1P),(BETIBR(1),BET1BR
     1),(SLIPI(1),SLIP1),(AM1I(1),AM11),(AM2I(1),AM21),(U0I(1),U01),
     1(FRIBR(2),FR2BR),(ALFI(2),ALF2),(BETIP(2),BET2P),(BETIBR(2),BET2BR
     1),(SLIPI(2),SLIP2),(AM1I(2),AM12),(AM2I(2),AM22),(U0I(2),U02),
     1(FRIBR(3),FR3BR),(ALFI(3),ALF3),(BETIP(3),BET3P),(BETIBR(3),BET3BR
     1),(SLIPI(3),SLIP3),(AM1I(3),AM13),(AM2I(3),AM23),(U0I(3),U03),
     1(FRIBR(4),FR4BR),(ALFI(4),ALF4),(BETIP(4),BET4P),(BETIBR(4),BET4BR
     1),(SLIPI(4),SLIP4),(AM1I(4),AM14),(AM2I(4),AM24),(U0I(4),U04),
     1(U1I(1),U11),(BAMI(1),BAM1),(SII(1),SI1),(SAMI(1),SAM1),(FI(1),F1)
     1,
     1(U1I(2),U12),(BAMI(2),BAM2),(SII(2),SI2),(SAMI(2),SAM2),(FI(2),F2)
     1,
     1(U1I(3),U13),(BAMI(3),BAM3),(SII(3),SI3),(SAMI(3),SAM3),(FI(3),F3)
     1,
     1(U1I(4),U14),(BAMI(4),BAM4),(SII(4),SI4),(SAMI(4),SAM4),(FI(4),F4)
      EQUIVALENCE (FXUI(1),FXU1),(FYUI(1),FYU1),(GI(1),G1),(FCI(1),FC1),
     1              (FXUI(2),FXU2),(FYUI(2),FYU2),(GI(2),G2),(FCI(2),FC2),
     1              (FXUI(3),FXU3),(FYUI(3),FYU3),(GI(3),G3),(FCI(3),FC3),
     1              (FXUI(4),FXU4),(FYUI(4),FYU4),(GI(4),G4),(FCI(4),FC4),
     1(FCIMAX(1),FC1MAX),(FSI(1),FS1),
     1(FCIMAX(2),FC2MAX),(FSI(2),FS2),
     1(FCIMAX(3),FC3MAX),(FSI(3),FS3),
     1(FCIMAX(4),FC4MAX),(FSI(4),FS4)
      EQUIVALENCE (ZIP(1),Z1P),(PHII(1),PHI1),
     1              (ZIP(2),Z2P),(PHII(2),PHI2),
     1              (ZIP(3),Z3P),(PHII(3),PHI3),
     1              (ZIP(4),Z4P),(PHII(4),PHI4)
      EQUIVALENCE (DL1S,DLIS(1)),(DL2S,DLIS(2)),(DL3S,DLIS(3))
     1              ,(DL4S,DLIS(4))
      REAL*4 MUP   ,MUS(2),PB(4),TFK(3),TRK(3),SII(4),APF(2),APR(2)
      REAL*4 LAFC,LAFT,LARC,LART
      REAL*4 AKTI(4)
      REAL*4 ATRACK(2000)
      REAL*4 BVALUE(2)
      REAL*4 IOUT(48),IN,ITMP,SCALAC(28),SCALDC(48)
      INTEGER*2 DACPLA(48),ADCPLA(28),ITRAA(50),ITRNA(50),ITRIA(50)
      INTEGER*2   RTSW  ,RBSW   ,LDTSW  ,OPEN
C     USE A/D READ VALUES
      DO 7413 I=1,28
      BVALUE(ADCPLA(I))=IN(I)*SCALAC(I)
 7413 CONTINUE
      DELFW1=-DELFW1
      DELFW2=-DELFW2
      IHSW=1
      TIME=FLOAT(JJTIME)*DT
      JJTIME=JJTIME+1
      ENTRY SBPG22
      ISW=1
      IF(TIME.GT.0.) GO TO 6
      DO 5 K=1,4
      FSI(K) = 0.
      ALTO(K) = 0.
      ZIMX(K) = 100.
    5 CONTINUE
      PHIDMX = 0.
    6 CONTINUE
C FUNCTION:  PSIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL
```

```
C           TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:    PSIFNT-(DEGREES/INCH)
C           DELI-(INCHES)
C     ******************************************************************
C     INCREASING THE SPRUNG MASS OVER THAT FOR WHICH THE STATIC WHEEL
C     DEFLECTION IS MEASURED, YIELDS A DELFIN AND A DELRIN WHICH
C     IS A NEGATIVE NUMBER
C     ******************************************************************
C     DELFIN AND DELRIN REPRESENT A CHANGE IN STATIC DISPLACEMENT
C     OF THE FRONT AND REAR WHEELS DUE TO LOAD CONFIGURATIONS
C OUTPUTS:   POLY-(DEGREES)
C
C     DLIS (I=1,2,3,4) IS THE SUSPENSION DEFLECTION RELATIVE
C           TO THE UNLOADED POSITION FOR WHEEL I
      DL1S = DEL1 + DELFIN
      DL2S = DEL2 + DELFIN
      DL3S = DEL3 + DELRIN
      DL4S = DEL4 + DELRIN
      IF(IAX.EQ.1) DL3S = DL3S   + TSO2*PHIR
      IF(IAX.EQ.1) DL4S = DL3S - TSO2*PHIR
      PSI1=DELFW1+(POLY(DL1S,PSIFNT)+EPSK1)*.01745329
      PSI2=DELFW2-(POLY(DL2S,PSIFNT)+EPSK2)*.01745329
      PSI3S = AKRS*PHIR
      PSI4S = AKRS*PHIR
C
C FUNCTION:  PHIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL
C           CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:    PHIFNT-(DEGREES/INCH)
C           DELI-(INCHES)
C
C OUTPUTS:   POLY-(DEGREES)
C
      PHI1=(POLY(DL1S,PHIFNT)+SIGN(FEE1,FS1))*.01745329
      PHI2=(-POLY(DL2S,PHIFNT)+SIGN(FEE2,FS2))*.01745329
      PHI3=PHIR
      PHI4=PHIR
C
C FUNCTION:  THEFNT-CASTER AS A FUNCTION OF SUSPENSION
C           DEFLECTION (DELI)
C
C INPUTS:    THEFNT (DEGREES/INCH)
C           DELI-(INCHES)
C
C OUTPUT:    POLY-(DEGREES)
C
      THS1=(POLY(DL1S,THEFNT)+THE1)*.01745329
      THS2=(POLY(DL2S,THEFNT)+THE2)*.01745329
      PHS1=YHS1+PHI1
      PHS2=YHS2+PHI2
      IF(IAX.EQ.1)GO TO 7843
C
C FUNCTION:  PSIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL
C           TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:    PSIRR-(DEGREES/INCH)
C           DELI-(INCHES)
C
C OUTPUTS:   POLY-(DEGREES)
```

```
C
      PSI3S = POLY(DL3S,PSIRR) * .01745329
      PSI4S = -POLY(DL4S,PSIRR) * .01745329
C
C FUNCTION:  PHIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL
C            CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:    PHIRR-(DEGREES/INCH)
             DELI-(INCHES)
C
C OUTPUTS:   POLY-(DEGREES)
C
      PHI3 =POLY(DL3S,PHIRR)*.01745329
      PHI4=-POLY(DL4S,PHIRR)*.01745329
 7843 CONTINUE
C     CALCULATION OF FRONT BUMP STOP FORCES
      IF(DL1S.LT.OFC) GO TO 21
      IF(DL1S.GT.OFT) GO TO 22
      FBS1 = 0.
      GO TO 23
   21 FBS1 = AKF*(LAFC - 1.)*(DL1S - OFC)
      GO TO 23
   22 FBS1 = AKF*(LAFT - 1.)*(DL1S - OFT)
   23 CONTINUE
      IF(DL2S.LT.OFC) GO TO 24
      IF(DL2S.GT.OFT) GO TO 25
      FBS2 = 0.
      GO TO 26
   24 FBS2 = AKF*(LAFC - 1.)*(DL2S - OFC)
      GO TO 26
   25 FBS2 = AKF*(LAFT - 1.)*(DL2S - OFT)
   26 CONTINUE
C     CALCULATION OF REAR BUMP STOP FORCES
      IF(DL3S.LT.ORC) GO TO 31
      IF(DL3S.GT.ORT) GO TO 32
      FBS3 = 0.
      GO TO 33
   31 FBS3 = AKR*(LARC - 1.)*(DL3S - ORC)
      GO TO 33
   32 FBS3 = AKR*(LART - 1.)*(DL3S - ORT)
   33 CONTINUE
      IF(DL4S.LT.ORC) GO TO 34
      IF(DL4S.GT.ORT) GO TO 35
      FBS4 =0.
      GO TO 36
   34 FBS4 = AKR*(LARC - 1.)*(DL4S - ORC)
      GO TO 36
   35 FBS4 = AKR*(LART - 1.)*(DL4S - ORT)
   36 CONTINUE
  100 TM1=Z-A*THE
      TM2=TRO2*PHI
      Z1PP=TM1+TM2
      Z1P=Z1PP+ZF
      Z1=Z1P+DEL1
      Z2PP=TM1-TM2
      Z2P=Z2PP+ZF
      Z2=Z2P+DEL2
      TM1=Z+B*THE
      TM2=TRO2*PHI
      Z3PP=TM1+TM2
```

```
      Z3P=Z3PP+ZR
      Z3=Z3P+DEL3
      IF(IAX.EQ.1) Z3=Z3+TRO2*PHIR+DEL3-DEL3
      Z4PP=TM1-TM2
      Z4P=Z4PP+ZR
      Z4=Z4P+DEL4
      IF(IAX.EQ.1) Z4=Z4-TRO2*PHIR+DEL3-DEL4
      DO 20 K=1,4
      RWZI(K) = RW + ZI(K)
      IF(RWZI(K).LT.ZIMX(K)) ZIMX(K) = RWZI(K)
      FRI(K) = 0.
      IF(RWZI(K).GT.0.) FRI(K) = AKTI(K) * RWZI(K)
   20 CONTINUE
      TM1=U+ZF*Q
      TM2=TFO2*R
      U1=TM1-TM2
      U2=TM1+TM2
      TM1=U+ZR*Q
      TM2=TRO2*R
      U3=TM1-TM2
      U4=TM1+TM2
      VARZFP=V+A*R-ZF*P
      VBRZRP=V-B*R-ZR*P
      PPHIR=P
      IF(IAX.EQ.1) PPHIR=P+PHIRD
      V1=VARZFP+Z1*P
      V2=VARZFP+Z2*P
      V3=VBRZRP+Z3*PPHIR
      V4=VBRZRP+Z4*PPHIR
      WAQ=W-A*Q
      WBQD3=W+B*Q+DEL3DT
      TF2P=TFO2*P
      TR2P=TRO2*P
      W1=WAQ+TF2P+DEL1DT
      W2=WAQ-TF2P+DEL2DT
      IF(IAX.EQ.2) GO TO 9738
      W3=WBQD3+TRO2*PPHIR
      W4=WBQD3-TRO2*PPHIR
      GO TO 9739
 9738 WBQD4=W+B*Q+DEL4DT
      W3=WBQD3+TR2P
      W4=WBQD4-TR2P
 9739 CONTINUE
      PSI3 = PSI3S+ ALTO(3)*AKSR
      PSI4 = PSI4S+ ALTO(4)*AKSR
      DO 30 K=1,4
      UGI(K) = UI(K) + THP*WI(K)
      VGI(K) = VI(K) - PHI*WI(K)
      SINPSI(K) = SIN(PSII(K))
      COSPSI(K) = COS(PSII(K))
      UGIP(K) = UGI(K) * COSPSI(K) + VGI(K) * SINPSI(K)
   30 CONTINUE
      CONVRT = 3600./(12.*5280.)
      CZ=COS(PSI)
      SN=SIN(PSI)
      DO 40 K=1,4
      CVI(K) = SQRT(UI(K)*UI(K) + VI(K)*VI(K))*CONVRT
      ABI(K) = ABS(UGI(K))
      BETAI(K) = ATAN(VGI(K)/ABI(K)) - PSII(K)*UGI(K)/ABI(K)
      SNI(K) = SNS0 / SNT
```

```
 40 CONTINUE
C     INTFUN IS USED FOR ROAD PATCH WITH VARING COEFFICENT OF FRICTION
      INTFUN=PARAM(172)+0.5
      IF(INTFUN.EQ.0)GO TO 3497
      IF(INTFUN.NE.1)GO TO 3498
      X1=A*CZ-TFO2*SN  +X
      X2=A*CZ+TFO2*SN  +X
      X3=-B*CZ-TRO2*SN +X
      X4=-B*CZ+TRO2*SN+X
      TEMP=PARAM(173)+PARAM(174)
      TEMP=TEMP*12.0
      PPPP=PARAM(173)*12.0
      IF(X1.GT.PPPP      .AND.X1.LE.TEMP)SN1=SNS1/SNT
      IF(X2.GT.PPPP      .AND.X2.LE.TEMP)SN2=SNS1/SNT
      IF(X3.GT.PPPP      .AND.X3.LE.TEMP)SN3=SNS1/SNT
      IF(X4.GT.PPPP      .AND.X4.LE.TEMP)SN4=SNS1/SNT
      GO TO 3498
3497 CONTINUE
      YY1=A*SN+TFO2*CZ  +Y
      Y2=A*SN-TFO2*CZ   +Y
      Y3=-B*SN+TRO2*CZ +Y
      Y4=-B*SN-TRO2*CZ+Y
      IF(YY1.LT.0.0) SN1=SNS1/SNT
      IF(Y2.LT.0.0) SN2=SNS1/SNT
      IF(Y3.LT.0.0) SN3=SNS1/SNT
      IF(Y4.LT.0.0) SN4=SNS1/SNT
3498 CONTINUE
      RA23=RA2*RA3
      R2T=ROT*RA2
      RA20=RA0*RA2
C     CALCULATION OF SIDE FORCE FRICTION COEFF
C
C FUNCTION:  AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT
C
C INPUTS:    B1-(PARAM(85)),LOAD TERM COEFFICIENT OF LATERAL FRICTION
C            COEFFICIENT (1/LB)
C            B2-(PARAM(86)),VELOCITY TERM COEFFICIENT OF LATERAL
C            FRICTION COEFFICIENT (1/MPH)
C            B3-(PARAM(87)),CONSTANT TERM (UNITY)
C            B4-(PARAM(88)),QUADRATIC LOAD TERM(1/LB**2)
C            FRI-RADIAL TIRE FORCE (POUNDS)
C            CVI-VELOCITY OF VEHICLE (MPH)
C
C OUTPUT:    AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT (UNITY)
C
      DO 60 K=1,2
      KK = K + 2
      AMUI(K)=(B1*FRI(K)+B2*CVI(K)+B3+B4*FRI(K)*FRI(K))*SNT(K)
      RMI(K) = FRI(K) * AMUI(K)
      FRIBR(K) = AMIN(FRI(K),A2T)
C     ALFI IS THE DENOMINATOR FOR THE BETA BAR CALCULATION
      ALFI(K) = CA1*FRIBR(K)*(FRIBR(K) - CA2) - CA20
      IF(ALFI(K)/CA2.GE.0.) ALFI(K) =-1.0E-10
      PHICGI(K) = THE*SINPSI(K) + PHI*COSPSI(K) + PHIT(K)
     1 + AKCF*FSI(K)
      BETIP(K) = CA23*(CA4-FRIBR(K))*FRIBR(K)*PHICGI(K)/(CA4*ALFI(K))
      IF(RMI(K).EQ.0.) GO TO 610
      BETIBR(K) = ALFI(K)*(BETAI(K) + BETIP(K))/(CA2*RMI(K))
      GO TO 710
 610 BETIBR(K) = 0.
```

```
  710 CONTINUE
      AMUI(KK) = (RB3 + RB1*FRI(KK) + RB2*CVI(KK) + RB4*FRI(KK)*FRI(KK))
     1 *SNI(KK)
      RMI(KK) = FRI(KK) * AMUI(KK)
      FRIBR(KK) = AMIN(FRI(KK),R2T)
      ALFI(KK) = RA1*FRIBR(KK)*(FRIBR(KK) - RA2) - RA20
      IF(ALFI(KK)/RA2.GE.0.) ALFI(KK) = 1.0E-10
      PHICGI(KK) = THE*SINPSI(KK) + PHI*COSPSI(KK) + PHII(KK)
     1 + AKCR*PSI(KK)
      IF(IAX.EQ.1) PHICGI(KK)=0.
      BETIP(KK)=RA23*(RA4-FRIBR(KK))*FRIBR(KK)*PHICGI(KK)/(RA4*ALFI(KK))
      IF(RMI(KK).EQ.0.) GO TO 630
      BETIBR(KK) = ALFI(KK)*(BETAI(KK) + BETIP(KK)) / (RA2*RMI(KK))
      GO TO 730
  630 BETIBR(KK) = 0.
  730 CONTINUE
   60 CONTINUE
      DO 11 K=1,4
      ABI(K) = ABS(BETIBR(K))
      IF(ABI(K).GE.3.) GO TO 10
      GBI(K) = BETIBR(K)*(1.-THRD*ABI(K)+TWN7*BETIBR(K)**2)
      GO TO 80
   10 GBI(K) = BETIBR(K)/ABI(K)
   80 CONTINUE
C     PARAM(314 -317) ARE EQUIVALENCED TO QUAN1 - 4
      SLIPI(K) = PARAM(K + 313)
      IF(SLIPI(K).LT.(-1.).OR.SLIPI(K).GT.1.) SLIPI(K)=SIGN(1.,SLIPI(K))
      SAMI(K) = (BETAI(K) + BETIP(K)) * 57.29578
   11 CONTINUE
C     CIRCUMFERENTIAL FRICTION COEFF CALCULATION
C
C             MUP- PEAK BRAKING COEF. OF FRICTION
C             MUS- SLIDING COEF. OF FRICTION
C             SII- SLIP RATIO AT WHICH PEAK BRAKING
C                  COEF. OF FRICTION OCCURS
C
C             SNI- RATIO OF SIM. VEHICLE SKID NUMBER SURFACE
C                   TO TIRE DATA SKID NUMBER SURFACE
C
C FUNCTION:    AM1I-RISE SLOPE OF UXI VS. WHEEL SLIP
C
C             SAMI- SIDE-SLIP ANGLE (DEGREES)
C             SI1-(PARAM(182),UNITY)
C             SI2-(PARAM(183),UNITY)
C             SI3-(PARAM (184),UNITY)
C             SI4-(PARAM(185),UNITY)
C
C             OUTPUT:    AM1I - UNITY
      DO 13 K=1,2
      KK=K+2
      MUP(K) = APF1 + APF2*FRI(K)
      MUP(KK) = APR1 + APR2 * FRI(KK)
      AM1I(K) = (MUP(K)/SII(K))*(1. - .03*ABS(SAMI(K)))
C **  MUS(1) EQUALS MUSF,MUS(2) EQUALS MUSR **
      IF(AM1I(K).LT.MUS(1)) AM1I(K) = MUS(1)
      AM1I(K) = AM1I(K) * SNI(K)
      AM1I(KK) = (MUP(KK)/SII(KK))*(1. - 0.03*ABS(SAMI(KK)))
      IF(AM1I(KK).LT.MUS(2))  AM1I(KK) = MUS(2)
      AM1I(KK) = AM1I(KK) * SNI(KK)
      AM2I(K) = ((MUS(1) - MUP(K))/(1. - SII(K)))*(1.-.06*ABS(SAMI(K)))
```

```
      IF(AM2I(K).GE.MUS(1)) AM2I(K) = MUS(1)
      AM2I(K) = AM2I(K) * SNI(K)
      AM2I(KK)=((MUS(2) -MUP(KK))/(1.-SII(KK)))*(1.-.06*ABS(SAMI(KK)))
      IF(AM2I(KK).GE.MUS(2))  AM2I(KK) = MUS(2)
      AM2I(KK) = AM2I(KK) * SNI(KK)
C OUTPUT:      U1I-VALUE OF UXI AT BRAKE SLIP = 1. (UNITY)
      U1I(K) = MUS(1) * SNI(K)
      U1I(KK) = MUS(2)  * SNI(KK)
C OUTPUT:      U0I-INTERCEPT OF UXI AT BRAKE SLIP = 0 (UNITY)
      U0I(K) = U1I(K) - AM2I(K)
      U0I(KK) = U1I(KK) - AM2I(KK)
  13  CONTINUE
      DO 12 K=1,4
      BAMI(K) = BETAI(K) + BETIP(K)
      XBM(K) = BAMI(K)
      SLP(K) = SLIPI(K)
C
C FUNCTION:  FCSI-SIDE FORCE SHAPING AS A FUNCTION OF SLIP
C
C INPUTS:    SAMI- SIDE-SLIP ANGLE (DEGREES)
C            SLP-SLIP (UNITY)
C            GAMF-SIDE FORCE SHAPING FUNCTION AS A FUNCTION OF
C            SLIP (UNITY)
C            AFA-BRAKING SLIP (UNITY)
C            NFA-NUMBER OF DATA POINTS
C
C OUTPUTS:   FCSI-LINEARLY ITERPOLATED SIDE FORCE SHAPING FUNCTION
C
      CSI(K) = FCSI(SAMI(K),SLP(K))
      FI(K) = CSI(K)
C            PARAM(306) TO (309) CIRCUM. FRICTION COEF.
      FXUI(K)= FRI(K)*(THE-PARAM(K+305)*COSPSI(K) - FI(K)*AMUI(K)
     1*SINPSI(K)*GBI(K))
      GI(K) = -PHI-PARAM(K+305)*SINPSI(K)+FI(K)*AMUI(K)*COSPSI(K)*GBI(K)
      FYUI(K) = FRI(K)*GI(K)
      FCI(K) = FRI(K)*PARAM(K+305)
      FCIMAX(K) = FRI(K)*AM1I(K)*SII(K)
      FSI(K) = FRI(K)*FI(K)*AMUI(K)*GBI(K)
   12 CONTINUE
C      ALIGNING TORQUE CALCULATIONS
C     OVER-TURNING MOMENT CALCULATIONS
      DO 4280 K=1,2
      KK= K+2
      ALTQ(K)=AFK1*FRI(K)*FSI(K)+SIGN(1.  ,FSI(K))*FSI(K)*FSI(K) *AFK2
     1 +SIGN(1.  ,PHICGI(K))*FRI(K)*SQRT(ABS(PHICGI(K))) *AFK3
      ALTQ(KK)=ARK1*FRI(KK)*FSI(KK)+SIGN(1.  ,FSI(KK))*FSI(KK)*FSI(KK)
     1*ARK2
     1 +SIGN(1.  ,PHICGI(KK))*FRI(KK)*SQRT(ABS(PHICGI(KK))) *ARK3
      OTM(K)=FRI(K)*(OFC1*FSI(K)+OFC2*FSI(K)*PHICGI(K)+OFC3*PHICGI(K))
      OTM(KK)=FRI(KK)*(ORC1*FSI(KK)+ORC2*FSI(KK)*PHICGI(KK)+ORC3
     1  *PHICGI(KK))
 4280 CONTINUE
      SALTQ=ALTQ(1)+ALTQ(2)+ALTQ(3)+ALTQ(4)
      FOTM=OTM(1)+OTM(2)
      ROTM=OTM(3)+OTM(4)
      SFXU=FXU1+FXU2+FXU3+FXU4
      SFYU=FYU1+FYU2+FYU3+FYU4
      SNPSIU=A*(FYU1+FYU2)-B*(FYU3+FYU4)+TRO2*(FXU2-FXU1)
     1    +TRO2*(FXU4-FXU3) + SALTQ
      IF(IAX.EQ.2)GO TO 4287
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      SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP                SBPG6000
     1       -FXU3*Z3PP-FXU4*Z4PP                                        SBPG6010
      SNPHIU=TFO2*(S2P-S1P)+TSO2*(S4P-S3P)+FYU1*(Z1PP+HFC)              SBPG6020
     1       +FYU2*(Z2PP+HFC)                                            SBPG6030
     1                                   -(FYU3+FYU4)*(DEL3+HRC+ZR)      SBPG6040
     1 + FOTM                                                            SBPG6050
      GO TO 4288                                                         SBPG6060
 4287 SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP                SBPG6070
     1       -FXU3*Z3PP-FXU4*Z4PP                                        SBPG6080
      SNPHIU=TFO2*(S2P-S1P)+TRO2*(S4P-S3P)+FYU1*(Z1PP+HFC)              SBPG6090
     1       +FYU2*(Z2PP+HFC)+FYU3*(Z3PP+HRC)+FYU4*(Z4PP+HRC)           SBPG6100
     1 + FOTM+ROTM                                                       SBPG6110
 4288 CONTINUE                                                           SBPG6120
C     KINEMATIC CALCULATIONS                                             SBPG6130
      GO TO (1000,1000,3000),ISW                                         SBPG6140
 1000 CONTINUE                                                           SBPG6150
      QDT=(SFXU/SM-SNTHEU/GAM2)*ONEOA                                    SBPG6160
      UDT=V*R-W*Q-G*THE-(A2*SFXU/SM-A1*SNTHEU/GAM2)*ONEOA               SBPG6170
      WDT=U*Q-V*P-(S1P+S2P+S3P+S4P)/AMS                                  SBPG6180
      TMP=W*P-U*R+G*PHI                                                  SBPG6190
      D1=SM*TMP+SFYU                                                     SBPG6200
      D2=-GAM3*TMP+SNPHIU                                                SBPG6210
        D3=GAM1*TMP+SNPSIU                                               SBPG6220
         VDT=(D1*F1+D2*GV1+D3*GV2)*ONEOD                                 SBPG6230
      PDT=(-D1*E2+D2*GP1+D3*GP2)*ONEOD                                   SBPG6240
      RDT=(D1*E3+D2*GR1+D3*GR2)*ONEOD                                    SBPG6250
      PHIDT=P+R*THE                                                      SBPG6260
      THEDT=Q-R*PHI                                                      SBPG6270
  101 PSIDT=R + Q*PHI                                                    SBPG6280
      XDT=U*CZ-V*SN                                                      SBPG6290
      YDT=U*SN+V*CZ                                                      SBPG6300
      ZDT=W-U*THE+V*PHI                                                  SBPG6310
      ANUMDT=(FC1+FC2+FC3+FC4)                                           SBPG6320
      ADENDT=(FC1MAX+FC2MAX+FC3MAX+FC4MAX)                               SBPG6330
      ISWPQ=PARAM(127)+0.5                                               SBPG6340
      ISWPQ=ISWPQ+1                                                      SBPG6350
      GO TO (7001,7002,7003,7004),ISWPQ                                  SBPG6360
      GO TO 7001                                                         SBPG6370
 7002 PDT=0.0                                                            SBPG6380
      GO TO 7001                                                         SBPG6390
 7003 QDT=0.0                                                            SBPG6400
      GO TO 7001                                                         SBPG6410
 7004 PDT=0.0                                                            SBPG6420
      QDT=0.0                                                            SBPG6430
 7001 CONTINUE                                                           SBPG6440
      GO TO (1100,1200),ISW                                              SBPG6450
 1100 CONTINUE                                                           SBPG6460
      IF(PARAM(180).EQ.1)                                                SBPG6470
     1GO TO 99100                                                        SBPG6480
      U = UO+UDT*DT                                                      SBPG6490
      V=VO+VDT*DT                                                        SBPG6500
      W=WO+WDT*DT                                                        SBPG6510
      P=PO+PDT*DT                                                        SBPG6520
      Q=QO+QDT*DT                                                        SBPG6530
      R=RO+RDT*DT                                                        SBPG6540
      X=XO+XDT*DT                                                        SBPG6550
      Y=YO+YDT*DT                                                        SBPG6560
      Z=ZO+ZDT*DT                                                        SBPG6570
      PHI=PHIO+PHIDT*DT                                                  SBPG6580
      THE=THEO+THEDT*DT                                                  SBPG6590
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      PSI=PSIO+PSIDT*DT
      ANUM=ANUMO+ANUMDT*DT
      ADEN=ADENO+ADENDT*DT
99100 CONTINUE
      UDTO=UDT
      VDTO=VDT
      WDTO=WDT
      PDTO=PDT
      QDTO=QDT
      RDTO=RDT
      PHIDTO=PHIDT
      THEDTO=THEDT
      PSIDTO=PSIDT
      XDTO=XDT
      YDTO=YDT
      ZDTO=ZDT
      ANUMDO=ANUMDT
      ADENDO=ADENDT
      IF(PARAM(180).EQ.1.)
     1GO TO 1200
      ISW=2
      GO TO 100
 1200 TLT=0.5*DT
      V=VO+TLT*(VDT+VDTO)
      W=WO+TLT*(WDT+WDTO)
      P=PO+TLT*(PDT+PDTO)
      Q=QO+TLT*(QDT+QDTO)
      R=RO+TLT*(RDT+RDTO)
      X=XO+TLT*(XDT+XDTO)
      Y=YO+TLT*(YDT+YDTO)
      Z=ZO+TLT*(ZDT+ZDTO)
      PHI=PHIO+TLT*(PHIDT+PHIDTO)
      THE=THEO+TLT*(THEDT+THEDTO)
      PSI=PSIO+TLT*(PSIDT+PSIDTO)
      U=UO+TLT*(UDT+UDTO)
      ANUM=ANUMO+TLT*(ANUMDT+ANUMDO)
      ADEN=ADENO+TLT*(ADENDT+ADENDO)
      PHIOUT=PHI+TLT*PHIDT
      THEOUT=THE+TLT*THEDT
      POUT=P+PDT*TLT
      QOUT=Q+QDT*TLT
      ROUT=R+RDT*TLT
      UOUT=U+UDT*TLT
      VOUT=V+VDT*TLT
      WOUT=W+WDT*TLT
      ZOUT=Z+ZDT*TLT
      XOUT=X+XDT*TLT
      YOUT=Y+YDT*TLT
      PDTOUT=0.5*(3.0*PDT-PDTO)
      QDTOUT=0.5*(3.0*QDT-QDTO)
      RDTOUT=0.5*(3.0*RDT-RDTO)
      PSIOUT=PSI+TLT*PSIDT
      UDTOUT=0.5*(3.0*UDT-UDTO)
      VDTOUT=.5*(3.*VDT-VDTO)
      WDTOUT=0.5*(3.0*WDT-WDTO)
      ANOUT=ANUM+TLT*ANUMDT
      ADOUT=ADEN+TLT*ADENDT
      PO=P
      QO=Q
      DDO=DD
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      RO=R
      UO=U
      VO=V
      WO=W
      XO=X
      YO=Y
      ZO=Z
      PHIO=PHI
      THEO=THE
      PSIO=PSI
      ANUMO=ANUM
      ADENO=ADEN
      IF(PARAM(180).EQ.1.)
     1GO TO 99120
      P=POUT
      Q=QOUT
      R=ROUT
      U=UOUT
      V=VOUT
      W=WOUT
      X=XOUT
      Y=YOUT
      Z=ZOUT
      PHI=PHIOUT
      THE=THEOUT
      PSI=PSIOUT
      ANUM=ANOUT
      ADEN=ADOUT
      IF(PARAM(180).EQ.2.)
     1GO TO 3000
      ISW=3
      GO TO 100
 3000 P=PO
      Q=QO
      R=RO
      U=UO
      V=VO
      W=WO
      X=XO
      Y=YO
      Z=ZO
      PHI=PHIO
      THE=THEO
      PSI=PSIO
99120 CONTINUE
C     STEERING AND BRAKING COMMANDS CALCULATED
      DSLM=PARAM(114)/PARAM(116)
      XTMP=PARAM(121)/PARAM(192)
      IF(PARAM(126).NE.0.0)GO TO 4321
      IF(TIME.GT.TST)GO TO 6000
      DELSWC=0.0
      GO TO 7000
 6000 DELSWC=(TIME-TST)*DSLM
      IF(ABS(DELSWC).GT.DSWCM) DELSWC=DSWCM*SIGN(1.0,DELSWC)
      IF(PARAM(128).EQ.3.0)GO TO 7000
      IF( TIME.GT.4.5 )DELSWC=DSWCM*(5.5-TIME)*SIGN(1.0,DELSWC)
 7000 DELSWC=DELSWC*.01745329
      PF=0.0
      IF(TIME.LT.TTI)GO TO 4444
      PF=(TIME-CGAM)*XTMP
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      IF(PARAM(128).EQ.1.0)GO TO 2223                                   SBPG7800
      IF(PARAM(128).EQ.3.0)GO TO 2223                                   SBPG7810
 2222 IF(PF.GT.PFL) PF=PFL                                              SBPG7820
      IF(TIME.LT.CGAM) PF=0.0                                           SBPG7830
      PFR=(TIME-CS)*XTMP                                                SBPG7840
      IF( TIME.GT.CS )PF=PF*(CS-TIME)/10.                               SBPG7850
      IF(TIME.LT.CS) PFR=0.0                                            SBPG7860
      IF(PFR.GT.PFL) PFR=PFL                                            SBPG7870
      IF( TIME.GT.CS )PFR=PFR*(CS-TIME)/10.                             SBPG7880
C                                                                      CSBPG7890
C FUNCTION:  FF-FRONT WHEEL BRAKE TORQUE AS A FUNCTION OF FRONT        CSBPG7900
C            BRAKE LINE PRESSURE                                       CSBPG7910
C                                                                      CSBPG7920
C INPUTS:    PFR-FRONT WHEEL BRAKE LINE PRESSURE (PSI)                 CSBPG7930
C            PBF-BRAKE LINE PRESSURE(PSI), ABSISSA USED IN LINEAR      CSBPG7940
C            INTERPOLATION SUBROUTINE                                  CSBPG7950
C            TQBF-FRONT WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE USED CSBPG7960
C            IN LINEAR INTERPOLATION SUBROUTINE                        CSBPG7970
C                                                                      CSBPG7980
C OUTPUTS:   FF-INTERPOLATED FRONT WHEEL BRAKE TORQUE AS A FUNCTION    CSBPG7990
C            OF FRONT BRAKE LINE PRESSURE                              CSBPG8000
C                                                                      CSBPG8010
      TQFBR=-FF(PF)                                                     SBPG8020
C                                                                      CSBPG8030
C FUNCTION:  FR-REAR WHEEL BRAKE TORQUE AS A FUNCITON OF REAR BRAKE    CSBPG8040
C            LINE PRESSURE                                             CSBPG8050
C                                                                      CSBPG8060
C INPUTS:    PFR-BRAKE LINE PRESSURE(PSI)                              CSBPG8070
C            PBR-BRAKE LINE PRESSURE (PSI),ABSISSA                     CSBPG8080
C            TQBR-REAR WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE       CSBPG8090
C                                                                      CSBPG8100
C OUTPUT:    FR-INTERPOLATED REAR WHEEL BRAKE TORQUE AS A FUNCTION     CSBPG8110
C            OF REAR BRAKE LINE PRESSURE                               CSBPG8120
C                                                                      CSBPG8130
      TQRBR=-FR(PFR)                                                    SBPG8140
      GO TO 2345                                                        SBPG8150
 2223 PF=(TIME-CGAM)*XTMP                                               SBPG8160
      IF(PF.GT.PFL) PF=PFL                                              SBPG8170
      PFR=(TIME-CGAM)*XTMP                                              SBPG8180
      IF(PFR.GT.PFL) PFR=PFL                                            SBPG8190
      TQFBR=-FF(PF)                                                     SBPG8200
      TQRBR=-FF(PFR)                                                    SBPG8210
      IF(TIME.LE.CGAM)TQFBR=0.                                          SBPG8220
      IF(TIME.LE.CGAM) TQRBR=0.                                         SBPG8230
      GO TO 2345                                                        SBPG8240
 4444 TQFBR=0.0                                                         SBPG8250
      TQRBR=AKTQP*(VC-UOUT)                                             SBPG8260
      IF(TQRBR.GT.TQMAXP) TQRBR=TQMAXP                                  SBPG8270
      GO TO 2345                                                        SBPG8280
 4321 CONTINUE                                                          SBPG8290
      DELSWC=SIN(3.141593*TIME)          *DSW*.01745329                 SBPG8300
      IF(TIME.GT.TSW) DELSWC=0.0                                        SBPG8310
      PF=0.0                                                            SBPG8320
      TQRBR=0.0                                                         SBPG8330
      TQFBR=0.0                                                         SBPG8340
      IF(PARAM(125).EQ.0.0)GO TO 2345                                   SBPG8350
      IF(TIME.LE.PARAM(278).OR.TIME.GT.PARAM(279))GO TO 2345            SBPG8360
      PF=(TIME-PARAM(278))*26000.0                                      SBPG8370
      IF(PF.GT.PFL) PF=PFL                                              SBPG8380
      TQRBR=-FR(PF)                                                     SBPG8390
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      TQFBR=-FF(PF)                                                     SBPG8400
 2345 CONTINUE                                                          SBPG8410
      IF(PARAM(193).NE.0.0)DELSWC=0.01745329*(PARAM(194)*YOUT+PARAM(195)SBPG8420
     1     *YDT)                                                        SBPG8430
      PTB1=PTBR                                                         SBPG8440
      PTB2=PTBR                                                         SBPG8450
      AKK1=1.0                                                          SBPG8460
      AKK2=1.0                                                          SBPG8470
      IF(PARAM(60).EQ.1.0) GO TO 4334                                   SBPG8480
      CALL PTBAK(BETA1,FR1,AKK1,PTB1)                                   SBPG8490
      CALL PTBAK(BETA2,FR2,AKK2,PTB2)                                   SBPG8500
 4334 CONTINUE                                                          SBPG8510
      AMT1=FXU1*(PTB1*SINPS1-YSA1*COSPS1-Z1*(PHI1*COSPS1-PHS1))         SBPG8520
     1   +FYU1*(-PTB1*AKK1*COSPS1-YSA1*SINPS1-Z1*(PHI1*SINPS1-THS1))    SBPG8530
     1     -FR1*(-PTB1*(PHS1*COSPS1+THS1*SINPS1)+YSA1*(THS1*COSPS1-     SBPG8540
     1       PHS1*SINPS1)-Z1*(PHS1*PHI1*SINPS1-THS1*PHI1*COSPS1))       SBPG8550
      AMT2=FXU2*(PTB2*SINPS2-YSA2*COSPS2-Z2*(PHI2*COSPS2-PHS2))         SBPG8560
     1   +FYU2*(-PTB2*AKK2*COSPS2-YSA2*SINPS2-Z2*(PHI2*SINPS2-THS2))    SBPG8570
     1     -FR2*(-PTB2*(PHS2*COSPS2+THS2*SINPS2)+YSA2*(THS2*COSPS2-     SBPG8580
     1       PHS2*SINPS2)-Z2*(PHS2*PHI2*SINPS2-THS2*PHI2*COSPS2))       SBPG8590
      AMT1 = SWMT*AMT1                                                  SBPG8600
      AMT2 = SWMT*AMT2                                                  SBPG8610
      NNN=PARAM(198)/(PARAM(75)*UOUT)+0.5                               SBPG8620
      XI(1)=XOUT+A*CZ-TFO2*SN                                           SBPG8630
      XI(2)=XOUT+A*CZ+TFO2*SN                                           SBPG8640
      XI(3)=XOUT-B*CZ-TRO2*SN                                           SBPG8650
      XI(4)=XOUT-B*CZ+TRO2*SN                                           SBPG8660
      NBMP=PARAM(277)+0.5                                               SBPG8670
      IF(NBMP.EQ.0) GO TO 8499                                          SBPG8680
      DO 8498 I=1,4                                                     SBPG8690
      DELX(I)=GETDEL(XI,I,PARAM(200),NBMP)                              SBPG8700
      GETDL = GETDL + DELX(I)                                           SBPG8710
 8498 CONTINUE                                                          SBPG8720
 8499 CONTINUE                                                          SBPG8730
C     CALCULATION OF ANTI PITCH AND ROLL FORCES                         SBPG8740
C     FOR SOLID AXLE DEL3 IS REAR AXLE VERTICAL ROLL CENTER             SBPG8750
C     DL3S AND DL4S ARE REAR WHEEL SUSPENSION DEFLECTIONS               SBPG8760
      AP1 = (CP0F + CP1F*DL1S + CP2F*DL1S*DL1S) * FXUT(1)               SBPG8770
      AP2 = (CP0F + CP1F*DL2S + CP2F*DL2S*DL2S) * FXUT(2)               SBPG8780
      AP3 = (CP0R + CP1R*DL3S + CP2R*DL3S*DL3S) * FXUT(3)               SBPG8790
      AP4 = (CP0R + CP1R*DL4S + CP2R*DL4S*DL4S) * FXUT(4)               SBPG8800
      AR1 = -(CR0F + CR1F*DL1S + CR2F*DL1S*DL1S) * FYUT(1)              SBPG8810
      AR2 =  (CR0F + CR1F*DL2S + CR2F*DL2S*DL2S) * FYUT(2)              SBPG8820
      AR3 = -(CR0R + CR1R*DL3S + CR2R*DL3S*DL3S) * FYUT(3)              SBPG8830
      AR4 =  (CR0R + CR1R*DL4S + CR2R*DL4S*DL4S) * FYUT(4)              SBPG8840
      ANTI1 = AP1 + AR1 - FBS1                                          SBPG8850
      ANTI2 = AP2 + AR2 - FBS2                                          SBPG8860
      ANTI3 = AP3 + AR3 - FBS3                                          SBPG8870
      ANTI4 = AP4 + AR4 - FBS4                                          SBPG8880
C     LONGITUDINAL AND LATERAL ACCELERATION CALCULATION                 SBPG8890
      ETAX=(UDTOUT-VOUT*ROUT+WOUT*QOUT)/386.4                           SBPG8900
      ETAL=(VDTOUT+ROUT*UOUT-WOUT*POUT)/386.4                           SBPG8910
      BTV=VOUT/UOUT                                                     SBPG8920
      BTVDT=(UOUT*VDTOUT-VOUT*UDTOUT)/(UOUT*UOUT)                       SBPG8930
      ONER=(ROUT+BTVDT)/SQRT(UOUT**2+VOUT**2)                           SBPG8940
C     COMPARISON VARIABLE DATA COLLECTION                               SBPG8950
      IF(IVHTP.GT.2) GO TO 402                                          SBPG8960
C     COMPARISON VARIABLES FOR VHTP # 1                                 SBPG8970
C     AXAVE = AVERAGE LONGITUDINAL DECELERATION                         SBPG8980
      IF(U.GT.(UIN-88.)) GO TO 400                                      SBPG8990
```

```
      AXI = AXI + ETAX
      GO TO 401
  400 TIMIN5 = TIME
  401 CONTINUE
      TIMDEC  = TIME - TIMIN5
  402 CONTINUE
      IF(IVHTP.NE.2) GO TO 412
C     VHTP #2 COMPARISON VARIABLES
C     AVERAGE PATH CURVATURE RATIO , CUVRAT
C     AVERAGE LONGITUDINAL DECELERATION, AXAVE
C     PEAK BODY SIDESLIP RATE, BETDMX
      IF (TIME.LT.CGAM) GO TO 410
      IF( TIME.GT.(CGAM + 1.)) GO TO 411
      CURVAV = CURVAV + ONER
      ABBTV = ABS(BTV)
      ABTVDT = ABS(BTVDT)
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT
      GO TO 411
  410 CURTBP = ONER
  411 CONTINUE
  412 CONTINUE
      IF(IVHTP.NE.3) GO TO 422
C     VHTP #3
      IF((GETDL.LE.0.).AND.(JUMP.EQ.0)) GO TO 420
      IF(TIME.GT.(TIMBMP + 1))   GO TO 421
      JUMP =1
      CURVAV = CURVAV + ONER
      ABTVDT = ABS(BTVDT)
      ABBTV  = ABS(BTV)
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      GO TO 421
  420 CURTBP = ONER
      TIMBMP =  TIME
  421 CONTINUE
  422 CONTINUE
      IF(IVHTP.NE.4) GO TO 432
C     VHTP #4  COMPARISON VARIABLES
      IF(TIME.LT.TST) GO TO 430
      IF(TIME.GT.(TST + 2.)) GO TO 431
      CURVAV = CURVAV + ONER
      ABTVDT = ABS(BTVDT)
      ABBTV  = ABS(BTV)
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      DELBET = BETAMX - BETA
      GO TO 431
  430 BETA = BTV
  431 CONTINUE
  432 CONTINUE
      IF(IVHTP.NE.5) GO TO 442
C     VHTP #5  COMPARISON VARIABLES
      IF(TIME.GT.3.4) GO TO 450
      IF(DSW.GT.0) GO TO 460
      DELSTR= DELSTR + ABS(Y + 144.)
      GO TO 461
  460 CONTINUE
      DELSTR=DELSTR + ABS(Y - 144.)
  461 CONTINUE
```

```
      ABBTV = ABS(BTV)
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      DELPSI = PSI
  450 CONTINUE
  442 CONTINUE
C     VHTP #6 COMPARISON VARIABLE
      IF(ABS(PHI).GT.PHIMAX) PHIMAX = ABS(PHI)
      IF(ABS(PHIDT).GT.PHIDMX) PHIDMX = ABS(PHIDT)
      IF(ABS(ETAL).GT.AYMAX) AYMAX= ABS(ETAL)
      IF(ABS(R).GT.RMAX) RMAX = ABS(R)
      FXL1=AML1*RRIM*ARPS1*ARPS1*WCTH1
      FXL2=AML2*RRIM*ARPS2*ARPS2*WCTH2
      FZL1=AML1*RRIM*ARPS1*ARPS1*WSTH1
      FZL2=AML2*RRIM*ARPS2*ARPS2*WSTH2
C     PREPARATION OF VARIABLES TO BE OUTPUT ON D/A CONVERTERS
      TEMP = (AMT1 + ALTQ(1)) / AIFW - RDTOUT
      TEMP=TEMP+(-FXL1*(YSA1+RWR/2.0))/AIFW
      IOUT(01)=- TEMP*SFOUT(9)*PARAM(175)
      TEMP=RZF+ZOUT-A*THEOUT+TFO2*PHIOUT
      TEMP=TEMP-DELX(1)
      IOUT(02)=TEMP*SFOUT(10)
      TEMP = (AMT2 + ALTQ(2))/ AIFW - RDTOUT
      TEMP=TEMP+(-FXL2*(YSA2+RWR/2.0))/AIFW
      IOUT(03)=- TEMP*SFOUT(9)*PARAM(175)
      TEMP=RZF+ZOUT-A*THEOUT-TFO2*PHIOUT
      TEMP=TEMP-DELX(2)
      IOUT(04)=TEMP*SFOUT(10)
      TEMP= (AM21-AM11)*0.05
      IOUT(05)=TEMP
      TM1=TFO2*PDTOUT
      TM2=A*QDTOUT
      TM3=CIP
      TEMP=-TM1+TM2+TM3-FYU1*SPSR3
      IOUT(06)=TEMP*SFOUT(14)*PARAM(175)
      TEMP= (AM22-AM12)*0.05
      IOUT(07)=TEMP
      TEMP= TM1+TM2+TM3+FYU2*SPSR3
      IOUT(08)=TEMP*SFOUT(14)*PARAM(175)
      IOUT(09)=-TQFBR*0.25*SFOUT(14)
      IOUT(10)=-TQRBR*0.25*SFOUT(14)
      IOUT(11)=DELSEC/10.0
      IOUT(12) = 0
      TEMP=(-TRO2-Z3*PHIR)
      IOUT(13)=TEMP*SFOUT(25)*PARAM(175)
      TEMP=CIVP-B*QDTOUT
      IOUT(14) =      TEMP*SFOUT(14)*PARAM(175)
      TEMP=(TRO2-Z4*PHIR)
      IOUT(15)=TEMP*SFOUT(27)*PARAM(175)
      TEMP=-PDTOUT-(FYU3*(TRO2*PHIR-Z3)+FYU4*(-TRO2*PHIR-Z4))/AIR
      TEMP = TEMP - ((FYU3+FYU4)*HRC - FOTM)/AIR
      IOUT(16)=TEMP*SFOUT(28)*PARAM(175)
      TEMP= (AM23-AM13)*0.05
      IOUT(17)=TEMP
      TEMP=(RZR+ZOUT+B*THEOUT+PHIOUT*TRO2)
      TEMP=TEMP-DELX(3)
      IOUT(18)=TEMP*SFOUT(10)
      TEMP= (AM24-AM14)*0.05
      IOUT(19)=TEMP
      TEMP=(RZR+ZOUT+B*THEOUT-PHIOUT*TRO2)
      TEMP=TEMP-DELX(4)
```

```
      IOUT(20)=TEMP*SFOUT(10)
      IOUT(21)  = U01*0.05
      IOUT(22)  = U02*0.05
      IOUT(23)  = AM11*.05
      IOUT(29)  = AM12*.05
      IOUT(25)=UG1P*SFOUT(37)
      IOUT(26)=UG2P*SFOUT(37)
      IOUT(27)=UG3P*SFOUT(37)
      IOUT(24)=UG4P*SFOUT(37)
      IOUT(28)  = U03*.05
      IOUT(30)  = U04*.05
      IOUT(31)  = AM13*.05
      IOUT(32)  = AM14*.05
      IOUT(33)  = -SI1
      IOUT(34)  = -SI2
      IOUT(35)  = -SI3
      IOUT(36)  = -SI4
      IOUT(37)=0
      IF(IAX.EQ.1)GO TO 7719
      TEMP    =G*(1.+A*AMS/(AMUR*(A+B)))-B*QDTOUT-TRO2*PDTOUT
     1         -FYU3*SPSR4
      IOUT(12)=TEMP*SFOUT(14)*PARAM(175)
      TEMP    =G*(1.+A*AMS/(AMUR*(A+B)))-B*QDTOUT+TRO2*PDTOUT
     1         +FYU4*SPSR4
      IOUT(37)=TEMP*SFOUT(14)*PARAM(175)
      IOUT(13)=C
      IOUT(16)=0
 7719 CONTINUE
      IF(UOUT.GE.25.0*5280.*12.0/3600.0)TIME25=TIME
      IF(UOUT.GE.10.0*5280.*12.0/3600.0)TIME10=TIME
      TEMPE=ABS(ROUT*57.29578)
      IF(TEMPE.GT.RMAX)RMAX=TEMPE
      TEMPE=ABS(ETAL)
      IF(TEMPE.GT.ETAMAX)ETAMAX=TEMPE
      TEMPE=ABS(PHIOUT*57.29578)
      IF(TEMPE.GT.PHIMAX)PHIMAX=TEMPE
      TEMPE=ABS(DELSWC*57.29578)
      IF(TEMPE.GT.DSWMAX)DSWMAX=TEMPE
      IF(TIME.LE.5.0)PSI5=PSIOUT*57.29578
      DO 3147 I=1,48
      DACO(I)=BVALUF(DACPLA(I))/SCALDC(I)
      SDACO=DACO(I)
      DACO(I)=AMAX1(-.9995,(AMIN1(.9995,DACO(I))))
      IF(SDACO.EQ.DACO(I))  GO TO 8317
      IDACK=IDACK+1
      IF(IDACK.GT.10)  IDACK=10
      IERDAC(IDACK)  =  I
      TERDAC(IDACK)=TIME
 8317 CONTINUE
 3147 CONTINUE
      IF(ABS(PSIOUT).GT.ABS(PSIM))PSIM=PSIOUT
      TEMPE=ABS(TORBR)
      IF(TEMPE.GT.TORMAX)TORMAX=TEMPE
      TEMPE=ABS(TOFBR)
      IF(TEMPE.GT.TOFMAX)TOFMAX=TEMPE
      TEMPE=ABS(PSIOUT)
      IF(TEMPE.GT.PSIMAX)PSIMAX=TEMPE
      NUMBR  =  NUMBR  +  1
C     DATA COLLECTION FOR TRACK OPTION
      IF(TIME.LT.(ONTIM-.00001))  GO TO 8185
```

```
      IF(TIME.GT.OFFTIM) GO TO 8185                                     SBPG0800
      IKEEP=IKEEP+1                                                     SBPG0810
      IF(IKEEP.NE.ISAMP) GO TO 8185                                     SBPG0820
      IKEEP=0                                                           SBPG0830
      DO 8199 I=1,ITRA                                                  SBPG0840
      J=ITRAA(I)                                                        SBPG0850
      JIN=JIN+1                                                         SBPG0860
      IF(JIN.GT.3999) JIN=3999                                          SBPG0870
      ATRACK(JIN)=BVALUE(J)                                             SBPG0880
 8199 CONTINUE                                                          SBPG0890
 8185 CONTINUE                                                          SBPG0900
      RETURN                                                            SBPG0910
      END                                                               SBPG0920
```

2.1.5 VHTPIC

PRESENTED HERE IS THE FORTRAN LISTING FOR THE VHTP INITIALIZATION SUBPROGRAM. THE APPROPRIATE ELEMENTS OF THE PARAM ARRAY ARE INITIALIZED IN VHTPIC FOR PERFORMANCE OF THE SELECTED VHTP.

```
C      SUBROUTINE VHTPIC
       SUBROUTINE VHTPIC
C      THIS SUBROUTINE INITIALIZES FOR A VHTP MANEUVER
       COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
       REAL*4 VHTPAR(27,7)
       INTEGER*4 PARMNO(27),SAVE/1/,NUMPRM/27/
       INTEGER*4 IONE/0/
       IF(IONE.GE.1) GO TO 40
       ICDRD = 1
       READ(ICDRD,100) (PARMNO(J),(VHTPAR(J,I),I=1,7),J=1,NUMPRM)
  100  FORMAT(I3,1X,7F10.3)
       IONE = IONE + 1
   40  CONTINUE
       I = IFIX(PARAM(129)) + 1
       IF(I.EQ.1) GO TO 10
       IF((I.GE.2).AND.(SAVE.NE.1)) GO TO 10
C      IF I = 1 ORIGINAL DATA MUST BE RESTORED
C      IF IIS NOT = 1 MUST DECIDE TO STORE DATA
C      IF I NE 1 AND OLD I NE 1 DO NOT STORE
       DO 20 J=1,NUMPRM
       VHTPAR(J,1) = PARAM(PARMNO(J))
   20  CONTINUE
   10  CONTINUE
       DO 30 J=1,NUMPRM
       PARAM(PARMNO(J)) = VHTPAR(J,I)
   30  CONTINUE
       SAVE = PARAM(129)
       IF(PARAM(129).EQ.4) PARAM(114)=PARAM(42)*((PARAM(6)+PARAM(7)))/60.
       IF(PARAM(129).EQ.5) PARAM(123)=66.*(PARAM(6)+PARAM(7))*PARAM(42)
      1 / (PARAM(66)*88.)
       IF(PARAM(129).EQ.6) PARAM(123)=PARAM(42)*(PARAM(6)+PARAM(7))
      1 / 7.5
       RETURN
       END
```

2.1.6 CMPVAR

PRESENTED HERE IS THE FORTRAN LISTING FOR THE COMPARISON VARIABLE (CV) CALCULATION SUBPROGRAM. THE CALCULATION AND OUTPUT OF THE CV'S ARE PERFORMED IN CMPVAR FOLLOWING EACH SIMULATION RUN.

```
C     SUBROUTINE CMPVAR
      SUBROUTINE CMPVAR
C     THIS SUBROUTINE CALCULATES THE COMPARISON VARIABLES
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBFT,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,       DT,       IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      DATA CURV1G/.00078/
      DATA LPTR/2/
C     CALCULATION OF COMPARISON VARIABLES
      IF(TIMDEC.EQ.0.) TIMDEC=.00000001
      IF(CURTBP.EQ.0. ) CURTBP=.00000001
      GO TO(1,2,3,4,5,6), IVHTP
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    1 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    2 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      CUVRAT =  CURVAV * DT/CURTBP
      GO TO 10
    3 CONTINUE
      CUVRAT = CURVAV * DT/CURTBP
      GO TO 10
    4 CONTINUE
      CUVRAT = CURVAV*.5*DT/CURV1G
      GO TO 10
    5 CONTINUE
      DEL= (DELSTR*DT/3.4)/12.
    6 CONTINUE
   10 CONTINUE
      RMAX = RMAX/57.3
      WRITE(LPTR,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBFT,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1'0AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1'0FTRQMAX=',F9.3,' RTRQMAX=',F9.3/)
      RETURN
      END
```

2.1.7 RTMON

PRESENTED HERE IS THE FORTRAN LISTING FOR THE REAL-TIME MODE INITIALIZATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN RTMON:

1) Initialization of order programs to perform real-time input/output.
2) Initiation of simulation runs.
3) Suspension of the simulation's OS processing until the real-time processing is completed.

```
C     SUBROUTINE RTMON
      SUBROUTINE RTMON
C     THIS SUBROUTINE INITIALIZES FOR REAL TIME OPERATION
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON /RBBLK/ AD2RB ,AD1RB ,CLSRB ,CLRRB ,ICRB  ,OPRB ,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON /ECBBLK/AD2ECB,AD1ECB,CLSECB,CLRECB,ICECB ,OPECB
      COMMON /ECBBLK/OSECB ,DONECB
      COMMON/ECBBLK/SLECB5,RLECB5
      COMMON/INOUT/INA(32),IOUTA(48),IN(32),IOUT(48),ISW1,ISW7,SFIN(32),
     1     SFOUT(48),IPRT,ITMP(48)
C
      REAL*8              PILRB(3)    ,LDARB(23)   ,TCNBUF(8)
      REAL*8      TIMBUF(8)
      REAL*8      SAVE2(16)   ,PILRB1(3)   ,AD2RB(6)    ,AD1RB(6)
      REAL*8      CLRRB(6)    ,OPRB(6)     ,TDARB(6)
      REAL*8      SAVE0(16)   ,SAVE1(16)   ,CLSRB(6)    ,ICRB(6)
      REAL*8   SLRB05(6),RLRB05(6)
C
      REAL*4      IOUT   ,IN     ,ITMP
      REAL*4      ADC2(04)    ,ADC1(24)
C
      INTEGER*4                TCNECB      ,TIMECB
      INTEGER*4   CONSL/01/   ,PILECB      ,ADAECB      ,TDAECB
      INTEGER*4   RCL0/00/    ,CLRECB      ,IMODOP/34/  ,OPECB
      INTEGER*4   F2/20/      ,L2/23/      ,FIRST/00/   ,LAST/47/
      INTEGER*4               NONE/00/     ,AD2ECB      ,AD1ECB
      INTEGER*4   SCL0/00/    ,CLSECB      ,IMODIC/06/  ,ICECB
      INTEGER*4     MONE/-1/    ,F1/00/     ,L1/23/
      INTEGER*4   TDAECB
      INTEGER*4   OSECB       ,DONECB
      INTEGER*4  SCL05/5/,RCL05/5/,SLECB5,RLECB5
C
      INTEGER*2               NUMEVT/03/ ,ZERO/00/
      INTEGER*2   UNIT/19/
      INTEGER*2 TWO/02/
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN  ,OPDN
C
      EQUIVALENCE (ADC1(24),IN(24))      ,(ADC2(1),IN(25))
C
      EXTERNAL          INIT,CART ,ENDRUN,HYBINT
C
      IF( RBSW.EQ.1 ) GO TO 200
         CALL BLJCB( 'J007',OSECB,NUMEVT,NONE )
         CALL DEFEP( INIT,SAVE0,ZERO,'NONE','NO' )
         CALL DEFEP( ENDRUN,SAVE1,ZERO,'NONE','NO' )
         CALL DEFEP( CART,SAVE2,ZERO,'NONE','NO' )
         CALL CRBCRB( F1,L1,ADC1,AD1RB,AD1ECB,CONSL )
         CALL CRBCRB( F2,L2,ADC2,AD2RB,AD2ECB,CONSL )
         CALL TLDARB( TDARB,TDAECB,CONSL )
         CALL SSCLRB( SCL0,CLSRB,CLSECB,CONSL )
         CALL SSCLRB(SCL05,SLRB05,SLECB5,CONSL)
         CALL RSCLRB( RCL0,CLRRB,CLRECB,CONSL )
         CALL RSCLRB(RCL05,RLRB05,RLECB5,CONSL)
         CALL SAMORB( IMODIC,ICRB,ICECB,CONSL )
         CALL SAMORB( IMODOP,OPRB,OPECB,CONSL )
         OPDN   = 0
```

```
      RBSW   = 1
  200 CONTINUE
      IF( RTSW.EQ.0 ) GO TO 210
      IF( OPDN.EQ.1 ) GO TO 205
         OPDN   = 1
         CALL RTOPN
         CALL RTACT( ZERO,'J007' )
  205 CONTINUE
         CALL DEFPR( UNIT,HYBINT,'J007' )
         LDTSW  = 0
         OSECB  = 0
         CALL RTACT( TWO ,'J007' )
         CALL WAITRT( OSECB )
         CALL WAITBU( 200 )
         CALL DEFPR( UNIT,MONE,'J007' )
      GO TO 215
  210 CONTINUE
         CALL LBDAFP( FIRST,LAST,IOUT,IERR )
         CALL TLDA
         CALL RSCL( SCLO,ICLERR )
         CALL CRBCFP( F2,L2,ADC2,ICRBCE )
         CALL SSCL( SCLO,ICLERR )
         CALL CRBCFP( F1,L1,ADC1,ICRBCE )
         CALL SBPG2
  215 CONTINUE
      RETURN
      END
```

2.1.8 RTIME

PRESENTED HERE IS THE FORTRAN LISTING OF THE REAL-TIME EXECUTIVE SUBPROGRAM. THE FOLLOWING IS PERFORMED IN RTIME:

1) Assignment of priority interrupt addresses to real-time events.

2) Initiation of the interval timer for computation cycle timing.

3) Execution of all real-time input/output.

4) Checks for end-of-run conditions.

5) Deactivation of real-time mode at the end of a simulation run.

```
C     SUBROUTINE RTIME
      SUBROUTINE RTIME
C     THIS SUBROUTINE PROVIDES THE REAL TIME SEQUENCING
      COMMON/APL/ OPEN   ,RTSW   ,LDTSW ,RBSW
      COMMON /RBBLK/ AD2RB ,AD1RB ,CLSRB ,CLRRB ,TCRB   ,OPRB  ,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB  ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON /ECBBLK/AD2ECB,AD1ECB,CLSECB,CLRECB,TCECB ,OPECB
      COMMON /ECBBLK/OSECB  ,DONECB
      COMMON/ECBBLK/SLECB5,RLECB5
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/INOUT/INA(32),IOUTA(48),IN(32),IOUT(48),ISW1,ISW7,SFIN(32),
     1      SFOUT(48),IPRT,ITMP(48)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/NONAME/XEND,O,EXIT2
      DIMENSION CSI(4),XBM(4),SLP(4)
      REAL*8       BUFF(8)     ,PILRB(3)    ,LDARB(23)   ,TCNBUF(8)
      REAL*8       TIMBUF(8)
      REAL*8                                 CLSRB(6)    ,TCRB(6)
      REAL*8                   PILRB1(3)   ,AD2RB(6)    ,AD1RB(6)
      REAL*8       CLRRB(6)    ,OPRB(6)     ,TDARB(6)
      REAL*8      BUFF1(8)
      REAL*8   SLRB05(6),RLRB05(6)
C
      REAL*4       IOUT   ,IN     ,ITMP
      REAL*4       ADC2(04)    ,ADC1(24)
C
      INTEGER*4    TIMCAN      ,TCNECB      ,TIMECB
      INTEGER*4    CONSL/01/   ,PILECB      ,ADAECB      ,TDAECB
      INTEGER*4                EVTRET/02/  ,TIMINT/120000/
      INTEGER*4 SLECB5,RLECB5 ,            FIRST/00/   ,LAST/47/
      INTEGER*4 CLRECB,OPECB,AD2ECB,AD1ECB,CLSECB,TCECB
      INTEGER*4    TDAECB      ,STATUS
      INTEGER*4    OSECB       ,DONECB
      INTEGER*4   PILCB1
C
      INTEGER*2    PILIST(2)/1,0/,EVTLST/1/
      INTEGER*2    TWO  /02/ ,ONE/01/
      INTEGER*2    RTSW   ,RBSW   ,LDTSW  ,OPEN
C
      EQUIVALENCE (ADC1(24),IN(24))       ,(ADC2(1),IN(25))
C
C     EVENT 0
C
      ENTRY INIT
         CALL PGET( PILIST, 0   ,'J007',PILRB1 )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         CALL PEVT( PILIST,EVTLST,'J007',PILRB )
         DONECB = 0
         CALL HWAIT( DONECB )
         CALL PREL( PILIST,'J007',PILRB1 )
         CALL HDONE( 'DN' )
      CALL HEXIT
```

```
C
C     EVENT 1
C
      ENTRY ENDRUN
      TCNECB = 0
         CALL RDTIMR( TIMCAN,TCNECB,'CANC',TCNBUF )
         CALL HIOCHK( TCNECB )
         PILECB = 0
         CALL PDAC( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
      ICECB  = 0
         CALL HIOREQ( ICRB )
         CALL HIOCHK( ICECB )
         CALL RTCAN( TWO   ,STATUS )
         CALL HCSPST( 'FN' )
      CALL HEXIT
C
C     EVENT 2
C
      ENTRY CART
      IF( LDTSW.EQ.1 ) GO TO 230
      PILCB1 = 0
         CALL PACT( PILIST,BUFF1,PILCB1 )
         CALL HIOCHK ( PILCB1 )
      TIMECB = 0
      TIMINT = 1.E06*DT/PARAM(175)
         CALL LDTIMR( TIMINT,TIMECB,EVTRET,TIMBUF )
      OPECB  = 0
         CALL HIOREQ( OPRB )
         CALL HIOCHK( OPECB )
         LDTSW  = 1
  230 CONTINUE
      SLECB5=0
      CLRECB = 0
      TDAECB = 0
      AD2ECB = 0
      CLSECB = 0
      AD1ECB = 0
         CALL HIOREQ(SLRB05)
         CALL HIOREQ( CLRRB )
         CALL HIOREQ( TDARB )
         CALL HIOREQ( AD2RB )
         CALL HIOREQ( CLSRB )
         CALL HIOREQ( AD1RB )
         CALL HIOCHK(SLECB5)
         CALL HIOCHK( CLRECB )
         CALL HIOCHK( TDAECB )
         CALL HIOCHK( AD2ECB )
         CALL HIOCHK( CLSECB )
         CALL HIOCHK( AD1ECB )
         CALL SPPG2
      ADAECB = 0
      RLECB5=0
         CALL LBDART( FIRST,LAST,IOUT,LDARB ,ADAECB,CONSL )
         CALL HIOREQ(RLRB05)
         CALL HIOCHK( ADAECB )
         CALL HIOCHK(RLECB5)
```

```
C     APL WILL TERMINATE REAL-TIME RUN IF EITHER
C     CONDITION SHOWN BELOW IS SATISFIED
      O=SQRT(U*U+V*V)
      IF(U.LE.0.1)CALL RTACT(ONE,'J007')
      IF(PHIMAX.GT.18.) CALL RTACT(ONE,'J007')
      IF(( ISW1.EQ.1 ).OR.( ISW7.EQ.1 )) CALL RTACT( ONE    ,'J007' )
      IF( TIME.LE.XEND.AND.O.GE.EXIT2 ) GO TO 250
      CALL RTACT( ONE,'J007' )
  250 CONTINUE
      CALL HEXIT
      RETURN
      END
```

2.1.9 ERMONT

PRESENTED HERE IS THE FORTRAN LISTING FOR THE ABNORMAL SIMULATION OPERATION SUBPROGRAM. THE CONDITIONS OF VEHICLE ROLL-OVER AND DIGITAL-TO-ANALOG CONVERTER OVERLOAD ARE DETECTED BY ERMONT WHEN SINGLE RUN EXECUTION IS PERFORMED.

```
C     SUBROUTINE ERMONT(MOPU,ORNAME,NAMDAC,IDAC,PHIMAX)
      SUBROUTINE ERMONT(MOPU,ORNAME,NAMDAC,IDAC,PHIMAX)
C     THIS SUBROUTINE CHECKS FOR ERROR CONDITIONS AT RUN TERMINATION
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20),IOR
      INTEGER*2         IDAC(48),NAMDAC(48)
      REAL*8 ORNAME(400)
      IF(PHIMAX.LT.18.) GO TO 200
      WRITE(MOPU,205) PHIMAX
  205 FORMAT(' VEHICLE ROLL OVER PHIMAX=',F8.2)
  200 CONTINUE
      IF(IDACK.LT.1) GO TO 100
      WRITE(MOPU,105)
      WRITE(MOPU,106)
      WRITE(MOPU,107) (TERDAC(J),ORNAME(NAMDAC(IERDAC(J))),
     1 IDAC(IERDAC(J)),J=1,IDACK)
  105 FORMAT(' DAC OVERLOAD')
  106 FORMAT('  TIME        VAR')
  107 FORMAT(F8.2,2X,A6,'(',I4,')')
  100 CONTINUE
      RETURN
      END
```

2.1.10 POTCHK

PRESENTED HERE IS THE FORTRAN LISTING FOR THE POTENTIOMETER SETTING CHECK SUBPROGRAM. CORRECT SETTING OF EACH POTENTIOMETER IS VERIFIED IN POTCHK. IF A SETTING ERROR IS DETECTED, APPROPRIATE OPTIONS OF CONTINUE, RETRY, OR RETURN TO THE OPTION COMMAND ARE PRESENTED TO THE USER.

```
C     SUBROUTINE POTCHK(IPOT,IVAL,ITCL,*,*)
      SUBROUTINE POTCHK(IPOT,IVAL,ITOL,*,*)
C     THIS SUBROUTINE CHECKS FOR INCORRECT POTENTIOMETER SETTINGS
C       IPOT IS THE POTENTIOMETER ADDRESS
C       IVAL IS THE POTENTIOMETER VALUE
C       ITOL IS THE POTENTIOMETER SETTING TOLERANCE
C       THE ASTERISKS(*) IN THE ARGUMENT LIST ARE DUMMY STATEMENT LABLES
C       CORRESPONDING TO THE AMPERSANDS(&) LABLE STATEMENTS IN CALLING
C       PROGRAM
C
      KEYBD = 5
      ITTY  = 6
      ITOL = 3
  100 CALL SPOT(IPOT,IVAL,ITOL,ISPOTE)
C       CHECK FOR POT FAILURE   ***
      IF(ISPOTE.EQ.0) GO TO 200
C
C       WRITES OUT NUMBER AND VALUE OF POT THAT FAILED  ***
      WRITE(ITTY,6000) IPOT,IVAL
 6000 FORMAT(1X,' POT',I3,T11,'DID NOT SET TO ',I5)
C
C       WRITES OUT PROGRAM OPTIONS FOR POT FAILURE  ***
      WRITE(ITTY,6010)
 6010 FORMAT(1X,' TYPE 1 (RETRY),2 (CONTINUE),3 (RESTART),4 (STOP)')
C
C       READS IN PROGRAM RETURN OPTIONS IN I1 FORMAT  ***
      READ(KEYBD,6020) I
 6020 FORMAT(I1)
C
C       GO TO STATEMENTS FOR PROGRAM RETURN OPTIONS  ***
      GO TO (100,200,300,400),I
C
C       PROGRAM RETURN STATEMENTS  ***
  200 RETURN
  300 RETURN 1
  400 RETURN 2
C       RETURN -   RETURN TO NEXT STATEMENT IN CALLING PROGRAM
C       RETURN 1&2 RETURNS TO THE 1ST&2ND (&) LABLE STATEMENTS IN THE
C       CALLING PROGRAM
C       FOR REFERENCE SEE IBM FORTRAN IV LANGUAGE MANUAL PAGES 96-98
      END
```

2.2 FUNCTIONS

PRESENTED HERE IS THE FORTRAN LISTING FOR THE FUNCTION SUBPROGRAMS CALLED BY THE MODEL SUBPROGRAM. THE FOLLOWING LIST DETAILS THE FUNCTION NAMES AND THEIR USE:

FUNCTION	USE
FF	Calculation of Front Wheel Brake Torque
FR	Calculation of Rear Wheel Brake Torque
FCSI	Calculation of the Wheel Slip Side Force Shaping Function
PTBAK	Calculation of a Caster Trail Function
GETDEL	Calculation of Bumps for VHTP #3
XINT	Linear Interpolation of Function Values between Input Table Data Points
AMIN	Selection of the Minimum Value between Two Variables
POLY	Evaluation of a Fifth-Order Polynomial Approximation to a Function

```
C     FUNCTION FF(P)
      FUNCTION FF(P)
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FF=XINT(P,PBF,TQBF,NTF)
      RETURN
      END
```

```
C     FUNCTION FR(P)
      FUNCTION FR(P)
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FR=XINT(P,PBR,TQBR,NTR)
      RETURN
      END
```

```
C     FUNCTION FCSI(GAMI,SIPI)
      FUNCTION FCSI(GAMI,SLPI)
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      TMP=ABS(SLPI)
      FCSI = XINT(TMP,GAMF,AFA,NFA)
      RETURN
      END
```

```
C     SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
      SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
      COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
      AP5=600.
      AKKI=AP4+FRI/AP5
      TEMP=ABS(BET*57.29578)
      PTBI=AP1
      IF(TEMP.LE.BTC1) RETURN
      PTBI=AP3
      IF(TEMP.GT.BTC2) RETURN
      PTBI=AP1*(1.0-(TEMP-BTC1)*AP2)
      RETURN
      END
```

```
C     FUNCTION GETDEL(X,I,R5,NBMP)
      FUNCTION GETDEL(X,I,R5,NBMP)
C     THIS SUBROUTINE PRODUCES THE BUMPS FOR VHTP #3
      COMMON/XBS/XB(15),NS(4,15),DELX(4),XT(4),NNN
      COMMON/XYZ/NUMBR
      DIMENSION X(4)
      GETDEL=0.0
      DO 10 K=1,NBMP
      L=NBMP-K+1
      IF(X(I).LE.XB(L))NS(I,L)=NUMBR+NNN
      IF(X(I).GE.XB(L).AND.NUMBR.LE.NS(I,L)) GO TO 20
   10 CONTINUE
      RETURN
   20 GETDEL=R5
      RETURN
      END
```

```
C     FUNCTION XINT(ARG,ARGTB,FUN,NP)
      FUNCTION XINT(ARG,ARGTB,FUN,NP)
C     THIS SUBROUTINE PERFORMS A LINEAR INTERPOLATION OF A FUNCTION
      DIMENSION ARGTB(NP),FUN(NP)
      DO 10 I=1,NP
      IF(ARG-ARGTB(I))30,20,10
   10 CONTINUE
      I=NP
   30 IF(I.EQ.1)I=2
      TEMP=(ARG-ARGTB(I-1))/(ARGTB(I)-ARGTB(I-1))
      XINT=FUN(I-1)+(FUN(I)-FUN(I-1))*TEMP
      RETURN
   20 XINT=FUN(I)
      RETURN
      END
```

```
C     FUNCTION AMIN(X,Y)
      FUNCTION AMIN(X,Y)
      IF(X-Y)1,1,2
    1 AMIN=X
      RETURN
    2 AMIN=Y
      RETURN
      END
```

```
C     FUNCTION POLY(DL,TBL)
      FUNCTION POLY(DL,TBL)
C     THIS SUBROUTINE PERFORMS A POLYNOMIAL APPROXIMATION TO A FUNCTION
      DIMENSION TBL(7)
      TMP=TBL(7)
      DO 10 I=1,6
      TMP=TMP*DL+TBL(7-I)
   10 CONTINUE
      POLY=TMP
      RETURN
      END
```

3. PRESENTED HERE ARE THE ANALOG COMPUTER DIAGRAMS

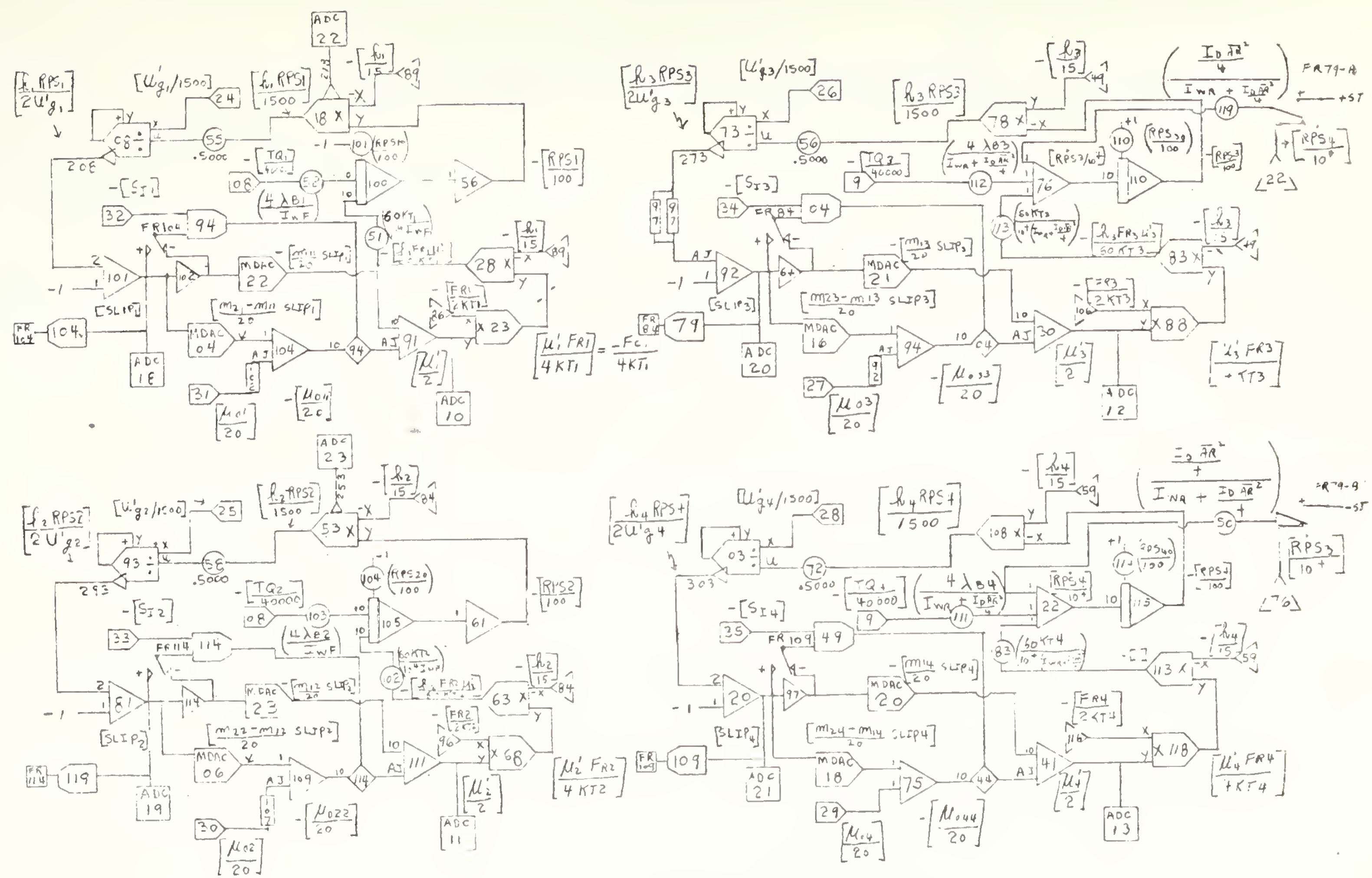


Fig. B-1 ANALOG COMPUTER DIAGRAM – ROTATIONAL WHEEL DYNAMICS

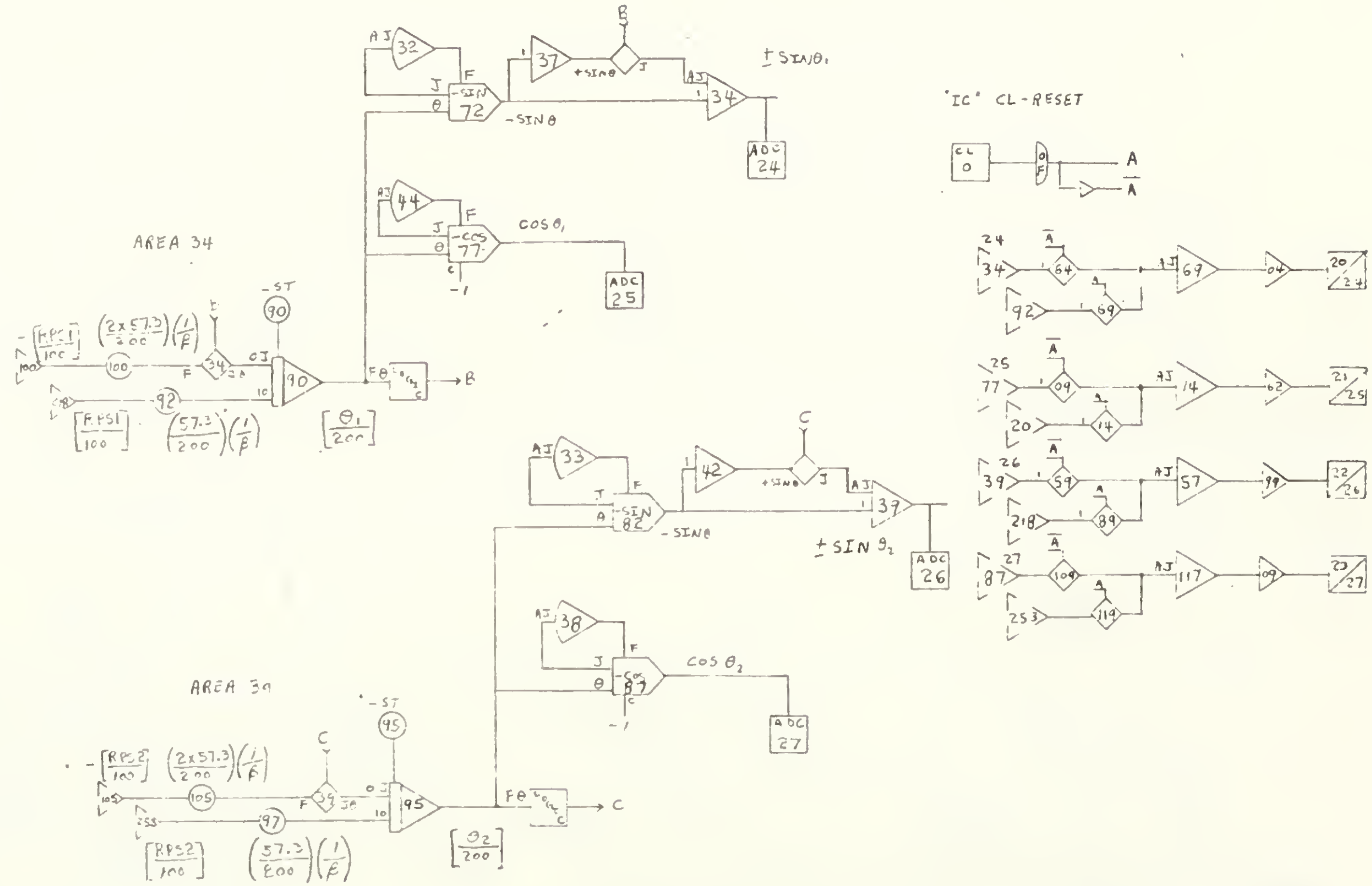


Fig. B-2 ANALOG COMPUTER DIAGRAM – CONTINUOUS RESOLUTION OF WHEEL RATES

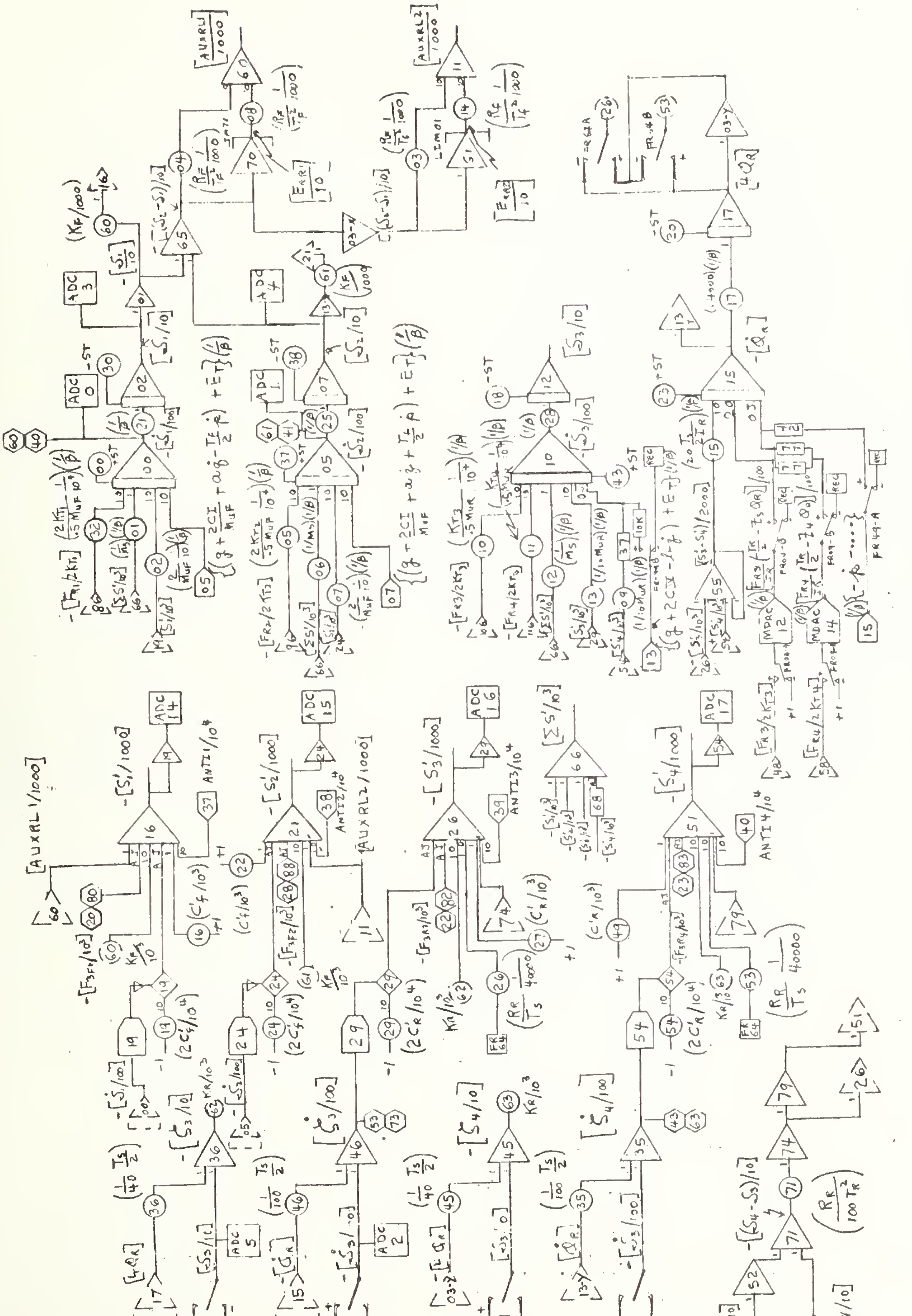
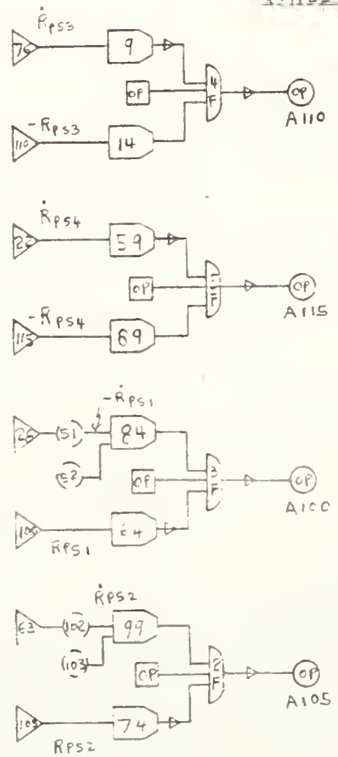


Fig. B-3 ANALOG COMPUTER DIAGRAM – SUSPENSION FORCES AND DEFLECTIONS

WHEEL-SLIP LOCKUP LOGIC



IC-INPUT	OP-INPUT	RESULTING MODE
1	ANY	IC
0	1	OP
0	0	HOLD

LOGIC TABLE

SOLID-SPLIT AXLE INTEGRATOR LOGIC

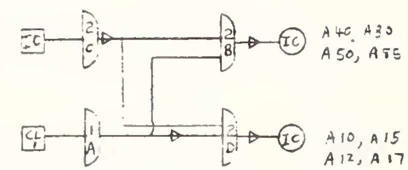


Fig. B-4 WHEEL LOCK-UP AND SPLIT/SOLID AXLE LOGIC

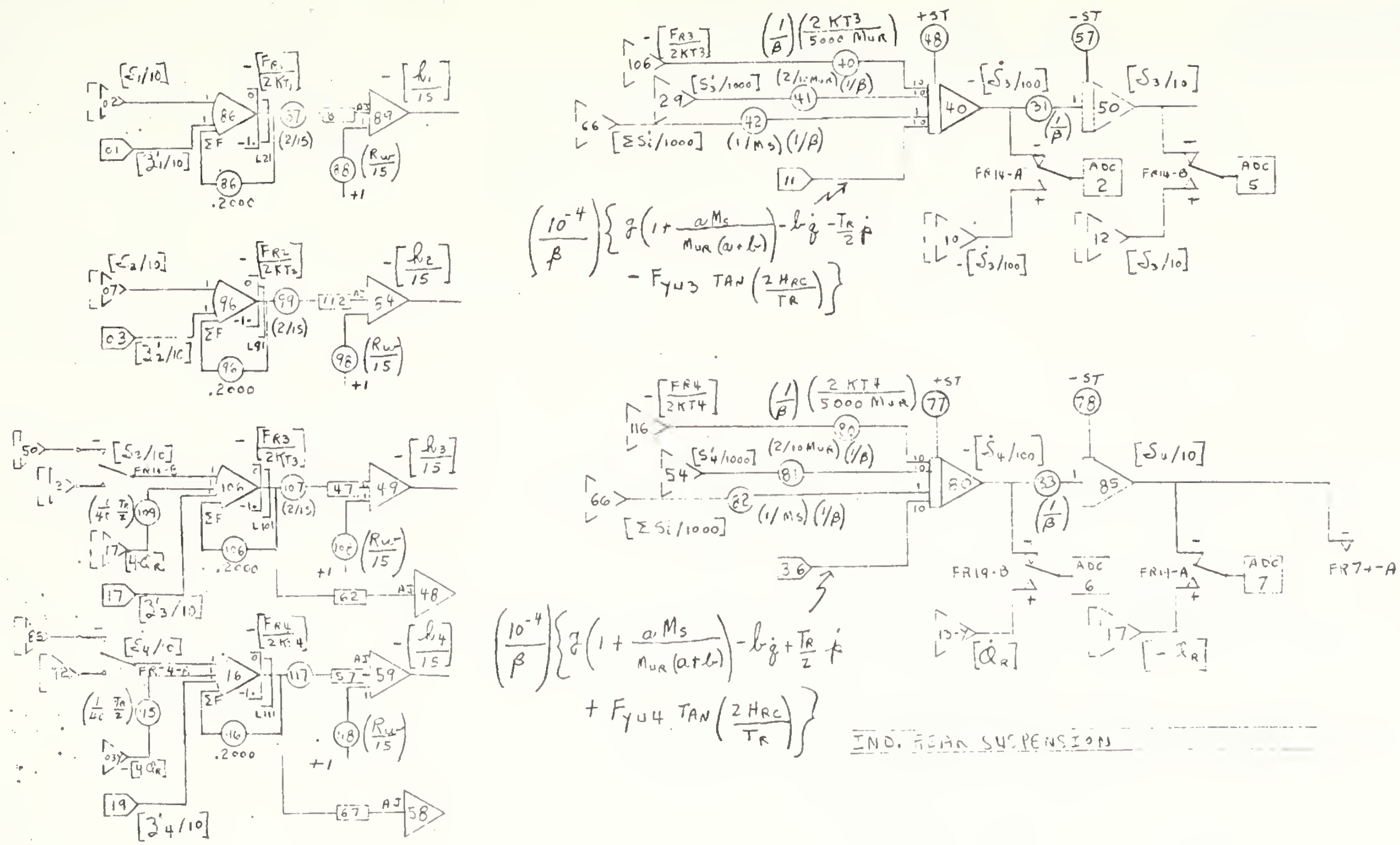


Fig. B-5 ANALOG COMPUTER DIAGRAM — RADIAL FORCES AND INDEPENDENT REAR SUSPENSION

231R-M

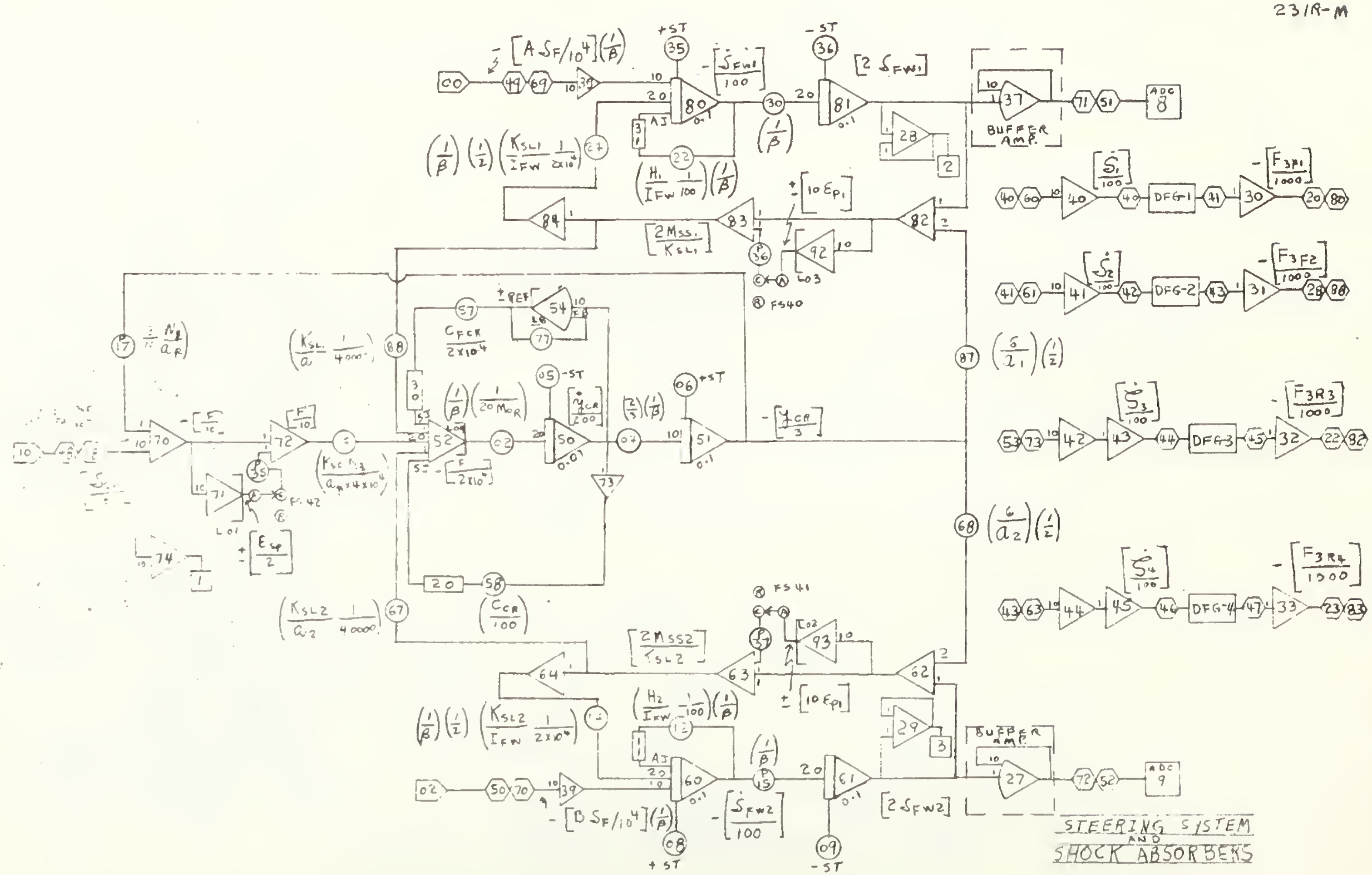


Fig. B-6 ANALOG COMPUTER DIAGRAM – STEERING SYSTEM AND SHOCK ABSORBERS

4. PRESENTED HERE ARE THE SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS. THE ORDER OF THE PARAMETERS CORRESPONDS TO THE INPUT DATA CARDS.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

Parameter Number	Symbol		Definition or Function (Units)
	Table	Equation	
001	MS	M_S	Total sprung mass (lb/in/sec^2)
002	MUF	M_{UF}	Total front unsprung mass (lb/in/sec^2)
003	MUR	M_{UR}	Total rear unsprung mass (lb/in/sec^2)
004	ZF	Z_F	Static distance between c.g. of sprung mass and spin axis of front wheels in z-direction (in)
005	ZR	Z_R	Static distance between c.g. of sprung mass and spin axis of rear wheels in z-direction (in)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x-direction (in)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x-direction (in)
008	TF	T_F	Front tread width (in)
009	TR	T_R	Rear tread width (in)
010	TS	T_S	Distance between rear axle spring mounts in y-direction (in)
011	IX	I_X	Roll moment of inertia of sprung mass (lb-in-sec^2)
012	IY	I_Y	Pitch moment of inertia of sprung mass (lb-in-sec^2)
013	IZ	I_Z	Yaw moment of inertia of sprung mass (lb-in-sec^2)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol		Definition or Function (Units)
	Table	Equation	
014	IXZ	I_{XZ}	Product of inertia of sprung mass (lb-in-sec^2)
015	IR	I_R	Roll moment of inertia of rear unsprung mass, exclude zero for computational purposes (lb-in-sec^2)
016	CF		Viscous damping coefficient for a single front wheel (lb-in-sec) (initialization)
017	RF	R_F	Auxiliary roll stiffness in front suspension (in-lb/radian)
018	CFPR	C'_F	Coulomb damping at each front wheel (lb)
019	KF	K_F	Front suspension spring rate (lb/in)
020	LAMF	λ_F	Front spring rate proportionality factor (initialization)
021	OMFC	Ω_{FC}	Suspension deflection for initial front wheel contact with compression bump stop (in)
022	OMFT	Ω_{FT}	Suspension deflection for initial front wheel contact with rebound bump stop (in)
023	CR		Viscous damping coefficient for a single rear wheel (lb-in-sec) (initialization)
024	RR	R_R	Auxiliary roll stiffness in rear suspension (in-lb/radian)
025	CRPR	C'_R	Coulomb damping at each rear wheel (lb)
026	KR	K_R	Rear suspension spring rate (lb/in)
027	LAMR	λ_R	Rear spring rate proportionality factor (initialization)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
028	OMRC	Ω_{RC}	Suspension deflection for initial rear wheel contact with compression bump stop (in)
029	OMRT	Ω_{RT}	Suspension deflection for initial rear wheel contact with rebound bump stop (in)
030	KRS	K_{RS}	Rear roll steer gain (rad/rad), (solid axle)
031	RW	R_W	Undeflected tire radius (in)
032			Unassigned
033	AOMT	$A\Omega_T$	Multiple of tire stiffness where cornering stiffness is constant, front wheels
034	A0	A_0	Constant coefficient in cornering stiffness function, front wheels
035	A1	A_1	Linear coefficient in tire cornering stiffness function, front wheels
036	A2	A_2	Quadratic coefficient in tire cornering stiffness function, front wheels
037	A3	A_3	Linear coefficient in tire camber stiffness function, front wheels
038	A4	A_4	Quadratic coefficient in tire camber stiffness function, front wheels
039 - 040			Unassigned
041	KSC	K_{SC}	Steering column-gear flexibility (in-lb/radian)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
042	NG	N_G	Gear ratio of steering gear box
043	LAFC	λ_{FC}	Front spring rate proportionality factor at compression bump stop
044	LAFT	λ_{FT}	Front spring rate proportionality factor at rebound bump stop
045	LARC	λ_{RC}	Rear spring rate proportionality factor at compression bump stop
046	LART	λ_{RT}	Rear spring rate proportionality factor at rebound bump stop
047	IFW	I_{FW}	Moment of inertia of front wheel about the king pin axis (in-lb-sec^2)
048			Unassigned
049	IWF	I_{WF}	Moment of inertia of front wheel about its spin axis (in-lb-sec^2)
050	IWR	I_{WR}	Moment of inertia of rear wheel about its spin axis (in-lb-sec^2)
051	ID	I_D	Moment of inertia of drive line about its spin axis (in-lb-sec^2)
052	AR	$\overline{AR}$	Drive axle ratio
053 - 054			Unassigned

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
055	PT	$\overline{PT}$	Front wheel caster trail (in)
056	YSA1	y_{SA1}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, right front (in)
057	YSA2	y_{SA2}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, left front (in)
058	PHS1	ϕ_{SA1}	Kingpin inclination angle, right front (radian)
059	PHS2	ϕ_{SA2}	Kingpin inclination angle, left front (radian)
060	CTSW		Caster trail switch: 060 = 1, constant; = 0, function
061 - 062			Unassigned
063 - 074			Initial conditions: $p,q,r,u,v,w,x,y,z,\theta,\phi,\psi$. Note that z_0 and θ_0 are computed values at t=0 and need not be specified.
075	DT		Integration step size (sec)
076	TN		Maximum run time (sec)
077 - 078	KTI	K_{Ti}	Tire spring rate, front wheels (lb/in)
079 - 080	KTI	K_{Ti}	Tire spring rate, rear wheels (lb/in)
081 - 084	RPSI	RPS_i	Initial wheel rotation rates computed at t=0 (rad/sec)
085	B1	B_1	Load term coefficient of lateral friction coefficient, front tire (1/lb)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
086	B2	B_2	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)
087	B3	B_3	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	B_4	Quadratic load term coefficient of lateral friction coefficient, front tire ($1/lb^2$)
089 - 091			Initial conditions: $\dot{\delta}_i, \delta_i, \dot{\phi}_R, \delta_{FWi}, \mu_{Xi}, S_i'$
092	DELF	δ_{FIN}	Static displacement change in front suspension due to vehicle load configuration (in)
093	DELR	δ_{RIN}	Static displacement change in rear suspension due to vehicle load configuration (in)
094 - 106			Initial conditions: $\dot{\delta}_i, \delta_i, \dot{\phi}_R, \delta_{FWi}, \mu_{Xi}, S_i'$
107	PPRT		Parameter table, print control: 107 = 1, print; = 0, no print
108 - 109			Unassigned
110	TQMX		Maximum available drive torque (in-lb)
111	KTQ	K_{TQ}	Drive torque gain factor (in-lb)/(in/sec)
112	VC	V_C	Commanded velocity (mph)
113	MTSW		Multiplier on front wheel aligning torque, M_{Ti}

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
114	DSWM	δ_{SW}	Maximum steering wheel angle (degrees), (except sinusoidal steer)
115	TST		Initial time of steer (sec), (except sinusoidal steer)
116	DSLP		Time to achieve maximum steer angle, equivalent to steer rate, exclude zero (sec), (except sinusoidal steer)
117	CGAM		Initial time of brake application (sec), (except drastic brake and steer)
118	CS		Initial time of brake application (sec), (except drastic brake and steer)
119	TQR	$\overline{TQ}_{Bi}$	Rear wheel brake torque (in-lb)
120	TQF	$\overline{TQ}_{Bi}$	Front wheel brake torque (in-lb)
121	PFL		Applied brake pressure (psi)
122	T1		Drive torque control (sec)
123	DSW		Sinusoidal steer amplitude (degrees)
124	TSW		Duration of sinusoidal steer (sec)
125	ISW5		VHTP sinusoidal steer enable code: 125 = 1, enable; = 0, disable
126	SW15		VHTP roll over enable code: 126 = 1, enable; = 0, disable
127	PQSW		Equation suppress option, 127 = 0, none; 1, $\dot{p} = 0$, 2, $\dot{q} = 0$; 3, $\dot{p} = \dot{q} = 0$

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
128	VTPS		VHTP switch
129	VHTP		VHTP index
130	AMCR	M_{CR}	Mass of steering system connecting rod (lb-sec^2/in)
131	ESP	ε_{SP}	Free play in steering gear box (rad)
132	KSL1	K_{SL1}	Steering linkage flexibility, right front wheel (in-lbs/radian)
133	KSL2	K_{SL2}	Steering linkage flexibility, left front wheel (in-lb/radian)
134 - 135	AAI	a_{Li}	Length of steering linkage arms (in)
136	CCR	C_{CR}	Viscous damping coefficient of steering system connecting rod (lb/in/sec)
137	CFCR	C_{FCR}	Coulomb damping of steering system connecting rod (lb)
138	AP	a_P	Length of Pitman arm (in)
139 - 140	EPI	ε_{Pi}	Free play in steer of front wheel (rad)
141 - 142	ERRI		Auxiliary roll stiffness play
143 - 144	AMLI	M_{li}	Unbalanced wheel mass (lb-sec^2/in)
145	RRIM	R_{RIM}	Wheel rim radius (in)
146	RWR	R_{WR}	Wheel rim width (in)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
147 - 168			Unassigned
169	SNT		Tire data surface skid number
170	SNS0		Simulated vehicle surface skid number
171	SNS1		Simulated vehicle surface skid number
172	SNSW		Skid patch switch: 172 = 2, disable; 1, front approach; 0, side approach
173	DIST		Initial distance between car and skid patch (in)
174	PL		Skid patch length (in)
175	TSCP		Computer time scale factor
176 - 179			Unassigned
180	PASS		Number of passes through integration routine
181			Unassigned
182 - 185	SII	SI_i	Wheel slip ratio at which peak braking coefficient of friction occurs
186 - 191			Unassigned
192	MTQB		Brake force rate, exclude zero for computational purposes (psi/sec)
193	DRSW		Driver control switch: 193 = 0, disable; 1, enable

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
194	LDF		Lateral displacement feedback gain (deg/in), 193 = 1
195	LDRF		Lateral displacement rate feedback gain (deg/in/sec), 193 = 1
196 - 197	EKI	ε_{Ki}	Static front wheel toe bias angles (degrees)
198	BMPL		Length of single road bump (in)
199	BMPS		Distance between road bumps (in)
200	BMPH		Road bump height (in)
201	XB		Initial distance from car to first bump (in)
202	APF1	P_{BF1}	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	P_{BF2}	Front tire peak braking coefficient of friction, linear term (1/lb)
204	APR1	P_{BR1}	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	P_{BR2}	Rear tire peak braking coefficient of friction, linear term (1/lb)
206	MUSF	μ_{SF}	Front tire sliding coefficient of friction
207	MUSR	μ_{SR}	Rear tire sliding coefficient of friction
208 - 218			Unassigned

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
219 - 220	FEEI	$\Delta\phi_i$	Front wheel camber bias angles (degrees)
221 - 222	THEI	$\Delta\theta_i$	Front wheel caster bias angles (degrees)
223 - 230			Unassigned
231 - 232	HI	H_i	Viscous damping derivative in front wheel (lb/in/sec)
233			Unassigned
234 - 235	AKFI	K_{Fi}	Front suspension spring rates (lb/in)
236 - 237	AKFJ	K_{Ri}	Rear suspension spring rates (lb/in)
238 - 241	BRI	λ_{Bi}	Brake torque multiplier for wheel i
242	KCF	K_{CF}	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	K_{CR}	Rear lateral force compliance camber coefficient (rad/lb)
244	KSR	K_{SR}	Rear aligning torque compliance steer coefficient (rad/in-lb)
245	RB1	RB_1	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	RB_2	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
247	RB3	RB_3	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	RB_4	Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$)
249	AFK1	A_{F1}	Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$)
250	AFK2	A_{F2}	Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$)
251	AFK3	A_{F3}	Aligning torque coefficient, front tire (in-lb/lb sq root (rad))
252	ARK1	A_{R1}	Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$)
253	ARK2	A_{R2}	Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$)
254	ARK3	A_{R3}	Aligning torque coefficient, rear tire (in-lb/lb sq root (rad))
255	OFC0	OF_0	Overturning moment coefficient, front tire (in-lb)
256	OFC1	OF_1	Overturning moment coefficient, front tire ($in\text{-}lb/lb^2$)
257	OFC2	OF_2	Overturning moment coefficient, front tire ($in\text{-}lb/lb^2\text{-}rad$)
258	OFC3	OF_3	Overturning moment coefficient, front tire (in-lb/lb-rad)
259	ORC0	OR_0	Overturning moment coefficient, rear tire (in-lb)
260	ORC1	OR_1	Overturning moment coefficient, rear tire ($in\text{-}lb/lb^2$)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol		Definition or Function (Units)
	Table	Equation	
261	ORC2	OR_2	Overturning moment coefficient, rear tire (in-lb/lb^2-rad)
262	ORC3	OR_3	Overturning moment coefficient, rear tire (in-lb/lb-rad)
263	CP0F	P_{F0}	Anti-pitch coefficient, front suspension (dimensionless)
264	CP1F	P_{F1}	Anti-pitch coefficient, front suspension, (1/in)
265	CP2F	P_{F2}	Anti-pitch coefficient, front suspension, (1/in^2)
266	CP0R	P_{R0}	Anti-pitch coefficient, rear suspension (dimensionless)
267	CP1R	P_{R1}	Anti-pitch coefficient, rear suspension (1/in)
268	CP2R	P_{R2}	Anti-pitch coefficient, rear suspension (1/in^2)
269	CR0F	R_{F0}	Anti-roll coefficient, front suspension (dimensionless)
270	CR1F	R_{F1}	Anti-roll coefficient, front suspension (1/in)
271	CR2F	R_{F2}	Anti-roll coefficient, front suspension (1/in^2)
272	CR0R	R_{R0}	Anti-roll coefficient, rear suspension (dimensionless)
273	CR1R	R_{R1}	Anti-roll coefficient, rear suspension (1/in)
274	CR2R	R_{R2}	Anti-roll coefficient, rear suspension (1/in^2)
275 - 276			Unassigned
277	BMPN		Number of bumps in bump grid

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol		Definition or Function (Units)
	Table	Equation	
278	TQB0		Time of brake application in combined drastic brake and steer VHTP
279	TQB1		Time of brake release in combined drastic brake and steer VHTP
280 - 283			Unassigned
284	HFC	h_{FC}	Distance between ground and the roll center of the front suspension (in)
285	HRC	h_{RC}	Distance between center of rear axle and the roll center of the rear suspension (in)
286			Unassigned
287	AXLE		Solid rear axle/split rear axle option code, solid=1, split=2
288 - 289			Unassigned
290	ROMT	$R\Omega_T$	Multiple of maximum tire load where cornering stiffness is constant, rear wheels
291	RA0	RA_0	Constant coefficient in tire cornering stiffness, rear wheels
292	RA1	RA_1	Linear coefficient in tire cornering stiffness function, rear wheels
293	RA2	RA_2	Quadratic coefficient in tire cornering stiffness function, rear wheels

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
294	RA3	RA_3	Linear coefficient in tire camber stiffness function, rear wheels
295	RA4	RA_4	Quadratic coefficient in tire camber stiffness function, rear wheels

5. PRESENTED HERE ARE THE SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS WHICH ARE VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
001	MS	M_S	Total sprung mass ($lb/in/sec^2$)
002	MUF	M_{UF}	Total front unsprung mass ($lb/in/sec^2$)
003	MUR	M_{UR}	Total rear unsprung mass ($lb/in/sec^2$)
004	ZF	Z_F	Static distance between c.g. of sprung mass and spin axis of front wheels in z-direction (in)
005	ZR	Z_R	Static distance between c.g. of sprung mass and spin axis of rear wheels in z-direction (in)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x-direction (in)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x-direction (in)
008	TF	T_F	Front tread width (in)
009	TR	T_R	Rear tread width (in)
010	TS	T_S	Distance between rear axle spring mounts in y-direction (in)
011	IX	I_X	Roll moment of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)
012	IY	I_Y	Pitch moment of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)
013	IZ	I_Z	Yaw moment of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
014	IXZ	I_{XZ}	Product of inertia of sprung mass (lb-in-sec^2)
015	IR	I_R	Roll moment of inertia of rear unsprung mass, exclude zero for computational purposes (lb-in-sec^2)
017	RF	R_F	Auxiliary roll stiffness in front suspension (in-lb/radian)
018	CFPR	C'_F	Coulomb damping at each front wheel (lb)
019	KF	K_F	Front suspension spring rate (lb/in)
020	LAMF	λ_F	Front spring rate proportionality factor (initialization)
021	OMFC	Ω_{FC}	Suspension deflection for initial front wheel contact with compression bump stop (in)
022	OMFT	Ω_{FT}	Suspension deflection for initial front wheel contact with rebound bump stop (in)
024	RR	R_R	Auxiliary roll stiffness in rear suspension (in-lb/radian)
025	CRPR	C'_R	Coulomb damping at each rear wheel (lb)
026	KR	K_R	Rear suspension spring rate (lb/in)
028	OMRC	Ω_{RC}	Suspension deflection for initial rear wheel contact with compression bump stop (in)
029	OMRT	Ω_{RT}	Suspension deflection for initial rear wheel contact with rebound bump stop (in)
030	KRS	K_{RS}	Rear roll steer gain (rad/rad), (solid axle)
031	RW	R_W	Undeflected tire radius (in)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
033	AOMT	$A\Omega_T$	Multiple of tire stiffness where cornering stiffness is constant, front wheels
034	A0	A_0	Constant coefficient in cornering stiffness function, front wheels
035	A1	A_1	Linear coefficient in tire cornering stiffness function, front wheels
036	A2	A_2	Quadratic coefficient in tire cornering stiffness function, front wheels
037	A3	A_3	Linear coefficient in tire camber stiffness function, front wheels
038	A4	A_4	Quadratic coefficient in tire camber stiffness function, front wheels
041	KSC	K_{SC}	Steering column-gear flexibility (in-lb/radian)
042	NG	N_G	Gear ratio of steering gear box
043	LAFC	λ_{FC}	Front spring rate proportionality factor at compression bump stop
044	LAFT	λ_{FT}	Front spring rate proportionality factor at rebound bump stop
045	LARC	λ_{RC}	Rear spring rate proportionality factor at compression bump stop

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
046	LART	λ_{RT}	Rear spring rate proportionality factor at rebound bump stop
047	IFW	I_{FW}	Moment of inertia of front wheel about the king pin axis (in-lb-sec^2)
049	IWF	I_{WF}	Moment of inertia of front wheel about its spin axis (in-lb-sec^2)
050	IWR	I_{WR}	Moment of inertia of rear wheel about its spin axis (in-lb-sec^2)
051	ID	I_D	Moment of inertia of drive line about its spin axis (in-lb-sec^2)
052	AR	$\overline{AR}$	Drive axle ratio
055	PT	$\overline{PT}$	Front wheel caster trail (in)
056	YSA1	Y_{SA1}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, right front (in)
057	YSA2	Y_{SA2}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, left front (in)
058	PHS1	ϕ_{SA1}	Kingpin inclination angle, right front (radian)
059	PHS2	ϕ_{SA2}	Kingpin inclination angle, left front (radian)
077 - 078	KTI	K_{Ti}	Tire spring rate, front wheels (lb/in)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
079 - 080	KTI	K_{Ti}	Tire spring rate, rear wheels (lb/in)
085	B1	B_1	Load term coefficient of lateral friction coefficient front tire (1/lb)
086	B2	B_2	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)
087	B3	B_3	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	B_4	Quadratic load term coefficient of lateral friction coefficient, front tire ($1/lb^2$)
092	DELF	δ_{FIN}	Static displacement change in front suspension due to vehicle load configuration (in)
093	DELR	δ_{RIN}	Static displacement change in rear suspension due to vehicle load configuration (in)
130	AMCR	M_{CR}	Mass of steering system connecting rod ($lb\text{-}sec^2/in$)
131	ESP	ϵ_{SP}	Free play in steering gear box (rad)
132	KSL1	K_{SL1}	Steering linkage flexibility, right front wheel (in-lbs/radian)
133	KSL2	K_{SL2}	Steering linkage flexibility, left front wheel (in-lb/radian)
134 - 135	AAI	a_{Li}	Length of steering linkage arms (in)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
136	CCR	C_{CR}	Viscous damping coefficient of steering system connecting rod (lb/in/sec)
137	CFCR	C_{FCR}	Coulomb damping of steering system connecting rod (lb)
138	AP	a_P	Length of Pitman arm (in)
139 - 140	EPI	ε_{Pi}	Free play in steer of front wheel (rad)
143 - 144	AMLI	M_{1i}	Unbalanced wheel mass ($lb\text{-}sec^2/in$)
145	RRIM	R_{RIM}	Wheel rim radius (in)
146	RWR	R_{WR}	Wheel rim width (in)
169	SNT		Tire data surface skid number
170	SNS0		Simulated vehicle surface skid number
171	SNS1		Simulated vehicle surface skid number
182 - 185	SII	SI_i	Wheel slip ratio at which peak braking coefficient of friction occurs
196 - 197	EKI	ε_{Ki}	Static front wheel toe bias angles (degrees)
202	APF1	P_{BF1}	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	P_{BF2}	Front tire peak braking coefficient of friction, linear term (1/lb)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
204	APR1	P_{BR1}	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	P_{BR2}	Rear tire peak braking coefficient of friction, linear term (1/lb)
206	MUSF	μ_{SF}	Front tire sliding coefficient of friction
207	MUSR	μ_{SR}	Rear tire sliding coefficient of friction
219 - 220	FEEI	$\Delta\phi_i$	Front wheel camber bias angles (degrees)
221 - 222	THEI	$\Delta\theta_i$	Front wheel caster bias angles (degrees)
231 - 232	HI	H_i	Viscous damping derivative in front wheel (lb/in/sec)
234 - 235	AKFI	K_{Fi}	Front suspension spring rates (lb/in)
236 - 237	AKFJ	K_{Ri}	Rear suspension spring rates (lb/in)
238 - 241	BRI	λ_{Bi}	Brake torque multiplier for wheel i
242	KCF	K_{CF}	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	K_{CR}	Rear lateral force compliance camber coefficient (rad/lb)
244	KSR	K_{SR}	Rear aligning torque compliance steer coefficient (rad/in-lb)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
245	RB1	RB_1	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	RB_2	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)
247	RB3	RB_3	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	RB_4	Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$)
249	AFK1	A_{F1}	Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$)
250	AFK2	A_{F2}	Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$)
251	AFK3	A_{F3}	Aligning torque coefficient, front tire (in-lb/lb sq root (rad))
252	ARK1	A_{R1}	Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$)
253	ARK2	A_{R2}	Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$)
254	ARK3	A_{R3}	Aligning torque coefficient, rear tire (in-lb/lb sq root (rad))
255	OFC0	O_{F0}	Overturning moment coefficient, front tire (in-lb)
256	OFC1	O_{F1}	Overturning moment coefficient, front tire ($in\text{-}lb/lb^2$)
257	OFC2	O_{F2}	Overturning moment coefficient, front tire ($in\text{-}lb/lb^2\text{-}rad$)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
258	OFC3	O_{F3}	Overturning moment coefficient, front tire (in-lb/lb-rad)
259	ORC0	O_{R0}	Overturning moment coefficient, rear tire (in-lb)
260	ORC1	O_{R1}	Overturning moment coefficient, rear tire (in-lb/lb^2)
261	ORC2	O_{R2}	Overturning moment coefficient, rear tire (in-lb/lb^2-rad)
262	ORC3	O_{R3}	Overturning moment coefficient, rear tire (in-lb/lb-rad)
263	CP0F	P_{F0}	Anti-pitch coefficient, front suspension (dimensionless)
264	CP1F	P_{F1}	Anti-pitch coefficient, front suspension, (1/in)
265	CP2F	P_{F2}	Anti-pitch coefficient, front suspension, (1/in^2)
266	CP0R	P_{R0}	Anti-pitch coefficient, rear suspension (dimensionless)
267	CP1R	P_{R1}	Anti-pitch coefficient, rear suspension (1/in)
268	CP2R	P_{R2}	Anti-pitch coefficient, rear suspension (1/in^2)
269	CR0F	R_{F0}	Anti-roll coefficient, front suspension (dimensionless)
270	CR1F	R_{F1}	Anti-roll coefficient, front suspension (1/in)
271	CR2F	R_{F2}	Anti-roll coefficient, front suspension (1/in^2)
272	CR0R	R_{R0}	Anti-roll coefficient, rear suspension (dimensionless)
273	CR1R	R_{R1}	Anti-roll coefficient, rear suspension (1/in)
274	CR2R	R_{R2}	Anti-roll coefficient, rear suspension (1/in^2)

Symbols and Definitions of the Program Parameters (cont'd.)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
284	HFC	h_{FC}	Distance between ground and the roll center of the front suspension (in)
285	HRC	h_{RC}	Distance between center of rear axle and the roll center of the rear suspension (in)
290	ROMT	$R\Omega_T$	Multiple of maximum tire load where cornering stiffness is constant, rear wheels
291	RA0	RA_0	Constant coefficient in tire cornering stiffness, rear wheels
292	RA1	RA_1	Linear coefficient in tire cornering stiffness function, rear wheels
293	RA2	RA_2	Quadratic coefficient in tire cornering stiffness function, rear wheels
294	RA3	RA_3	Linear coefficient in tire camber stiffness function, rear wheels
295	RA4	RA_4	Quadratic coefficient in tire camber stiffness function, rear wheels

APPENDIX C
DESCRIPTION OF HYBRID COMPUTER SIMULATION LABORATORY

1. HYBRID COMPUTER

The APL hybrid computer is unique in that the analog computer is a terminal to a large digital computer, with communication between them occurring over a 1000-foot data path. A block diagram of the system is presented in Figure C-1. The analog computer is an EAI Model 680 and the digital computer is an IBM System 360 Model 91. The data channel that provides the high-speed transmission required for hybrid processing is the parallel data adapter (PDA) of the IBM 2909 asynchronous data channel. The 2909, which is capable of transmitting at a 2M-byte per second rate, is working at about 40% of this rate (200K 16-bit words per second) through the PDA while servicing the hybrid. Besides the PDA, the 2909 has two additional subchannels used for hybrid processing: one for priority interrupts and the other for precision internal timing.

The priority interrupt subchannel provides up to 64 priority interrupt levels (PILS) for a System 360 which, with the exception of the 360/44, does not have a priority interrupt structure. Thus, this subchannel was necessary in order to provide the hybrid system with PILS. This subchannel currently is expanded to 16 PILS. The other subchannel provides a precision interval timer (1 μs resolution) to the hybrid user. This timer can be loaded via software and causes an interrupt when decremented to zero, which in turn initiates an event in a hybrid program.

The 360/91, one of the largest and fastest computers built by IBM, has the following characteristics:

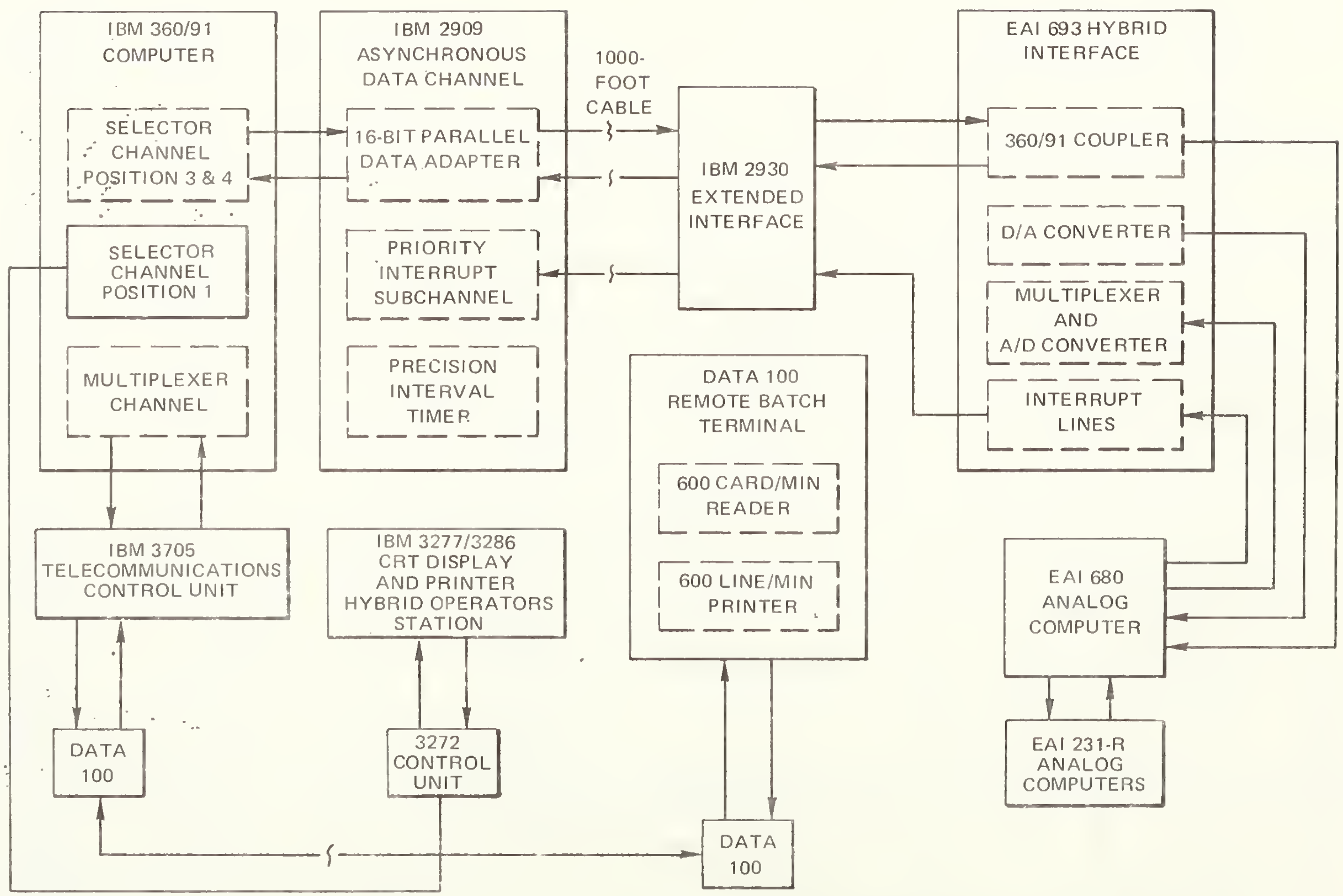


Fig. C-1 HYBRID SYSTEM BLOCK DIAGRAM

Third-generation hardware

4 million bytes of main core storage

1 trillion bytes of direct access storage

Minimum execution time of 60 ns per instruction

Use of the Operating System OS/MVT (Multiprogramming with a Variable Number of Tasks)

Two advantages are immediately obvious to a 360/91 interactive user. First, since he is only charged in proportion to his use of the central processing unit (CPU) and main core storage in the multi-programming environment, the machine is inexpensive to use. Second, since the 360/91 is a third-generation computer with nearly unlimited resources, it is extremely fast and efficient while computing. In summary, this computer gives the interactive terminal user unlimited digital resources at a cost comparable to that of a much smaller computer.

The Interactive Simulation Laboratory (ISL) is located 800 feet from the 360/91 digital computer. The 2909 PDA, which has specially designed line drivers and receivers (now standard from IBM), can easily drive the 1000-foot cable to the ISL. However, matching drivers and receivers are required in the ISL. These are housed in the IBM 2930. Individual lines are required for each bit of the data word, each control line, and for each PIL. The 2930 then cables into a 360/91 coupler (standard EAI product) housed within the EAI 693. From the coupler on, the 693 hybrid interface and 680 analog computer are standard EAI equipment.

In addition to the hybrid hardware of Figure C-1, the ISL contains three pieces of equipment that support the hybrid operations. These are a Data 100 remote batch terminal and

an IBM 3270 Display System (3286 printer and a 3277 CRT with a keyboard). The Data 100 consists of a 600 card/minute reader and a 600 line/minute printer which allow the submission of jobs to the 360/91 and the return of results from the 360/91 at the ISL hybrid work station. The Data 100 operates over a dedicated communications line into a control unit connected to the 360/91 multiplexer channel. Its support package is the IBM remote job processing (RJP) portion of the ASP job scheduler.

The IBM 3270 Display System has evolved as the hybrid operator's station. Via APL-written software, all hybrid jobs can be interfaced to the Display System and problem execution directed from the CRT and input keyboard. In addition, the operator's station contains a 3286 (66 character per second) printer. All CRT activities, input and output, are recorded on this printer. The printer also serves as an addressable output device.

These hardware items comprise the APL hybrid computer system. In addition to this system, the ISL contains three 231-R analog computers, each interfaced to an EAI DES-30 logic unit and an EAI quarter-square multiplier rack. These machines are interfaced to the hybrid system via buffering amplifiers for large simulations.

2. HYBRID SOFTWARE

Included with the original EAI hardware purchase were three hybrid software packages operable under Operating System 360 (OS/360). The first, the HYIOS (Hybrid Input/Output Subroutines) package, was a collection of Fortran IV callable

subroutines that allowed operation from the 360 of all hybrid functions in the 680 and 693 originally designed for control from the EAI PACER 100 digital computer (Ref. 8). These routines number 47 and permit complete control and readout of the data interface, logic components, and analog components. Also, these routines do extensive error checking and each has an error argument returned, which can be checked by the programmer to determine successful completion of a hybrid operation.

The second software package delivered by EAI was HYSAT (Hybrid Static Analog Test). HYSAT is an interpretive language written in Fortran using HYIOS, which automates the performance of analog computer setup and static checks. Simple commands allow changing the analog mode, setting potentiometers and control lines; reading the outputs of amplifiers, integrator derivatives, and track-store inputs; and reading the state of sense lines, comparators and relays. In the verify mode, the outputs of the analog and logic components can be compared against predetermined values, with all errors documented on the CRT. This program is interactive from the CRT/keyboard and input from a prepared data set can be selected. The capabilities of HYSAT have been combined with ease of programming of a simulation language (DSL/91) to produce a completely automated static check procedure for hybrid programs (Ref. 7). A specially wired board and specially prepared HYSAT data deck are used to verify that all 680 analog components are operational.

Whereas HYSAT permits checking the 680 analog console statically, the third software package delivered by EAI permits checking the 693 hybrid interface. HIORT (hybrid Interface Operational Readiness Test) is again an interpretive

language that is interactive at the CRT and is used to perform A/D converter absolute error tests and A/D - D/A converter relative error tests. With this program, information is obtained to demonstrate the functioning, within specification, of the hybrid interface.

Thus, with these three software packages, complete hybrid programming is obtained. HYIOS provides the Fortran callable routines for application programs; HYSAT provides a a convenient interactive method for performing initial setup and static checks; and HIORT provides an interactive method of insuring the accuracy of the hybrid interface. These programs are fully documented in Ref. 8.

3. REAL-TIME HYBRID

The multiprogramming 360/91 is a great asset for the hybrid user in that it provides nearly unlimited digital resources and inexpensive operation. However, when real-time hybrid is considered, multiprogramming becomes a liability. Since many users are timesharing the facilities of the large central processor, service within a fixed time frame cannot be guaranteed. From the beginning, it was obvious that a hypervisor was required for real-time jobs.

This need has been met by IBM's real time monitor (RTM). RTM was developed at the IBM Palo Alto DACS Development Center and was first reported in a seminar at the DACS Center in September 1968 (Ref. 9). As first reported, RTM guarantees CPU service to jobs designated as real-time jobs, with RTM co-resident with the OS/360 monitor. The real-time job can use all the facilities of OS and can force all non-real time

jobs into the "wait state" when it needs the CPU. IBM augmented their basic RTM with the code required, to have RTM support the PDA, precision interval timer, and priority interrupt subchannels of the IBM 2909. These packages provide Fortran callable subroutines as well as assembly language MACRO'S for accessing and controlling the three subchannels. RTM is a "free" IBM software package installable on IBM System 360 and 370 computers; it was released in December 1970. Reference 10 is an introduction to RTM and Reference 11 is the RTM Operations and Programmer's Guide.

Many applications programs have been written using the real time monitor in which two basic types of operation are employed: (a) initialization of real-time events via the priority interrupts and (b) the initialization of real-time events via decrementing of the interval timer. Besides the conventional closed-loop hybrid technique of executing a digital program involving A/D conversion, digital calculation and D/A conversion; an interrupt-based, multiplying D/A converter, hybrid function generation scheme (Ref. 12) has also been implemented. In order to complete support of these real-time hybrid jobs, the HYIOS subroutines were rewritten to run under RTM as well as OS/360. These routines are referred to as RTAM (Real Time Access Method). During this effort, much of the error checking in these routines was omitted, greatly decreasing the execution time of each routine.

As an aid for preparing real-time simulations, APL has written an interactive program which generates all RTM and RTAM subroutine calls. The input to this program is the hybrid resources required for the simulation, such as number of D/A and A/D converters and their addresses, control lines

to be set or reset, etc. The output of the program is a compilable Fortran IV source program that serves as the base for the digital portion of the hybrid simulation (Ref. 13).

4. HYBRID OPERATION

Two modes of hybrid operation are currently employed: closed-loop real-time hybrid and data acquisition. In both cases the hybrid jobs are submitted to the 360/91 via the Data 100. If it is a real-time job, the hybrid applications engineer must have RTM started prior to the release of his application program. Both real-time and data acquisition jobs are run interactively at the CRT and jobs are available within minutes of submission.

Hybrid data acquisition programs are those that use the digital computer to vary parameters interactively between runs, collect data at the end of a run, and then post-process the data to determine a cost function in an all-analog simulation. No real-time constraint exists in this type of running. Stochastic variation (white noise) is usually an input and many runs are required to statistically define a data point. The digital computer response is gotten by forcing the 360/91 program into the "wait state" for the analog solution time which immediately follows the change of the analog mode to operate. Following the "wait," data is collected and simulation control is returned to the user at CRT. This mode has been quite reliable and control is immediately returned following the "wait." Non-real time jobs operate under OS/360 at an execution priority of 11 out of 13, using the HYIOS routines supplied by EAI. As previously mentioned, all real-time jobs operate under RTM in the manner discussed.

All simulations, either data acquisition or hybrid, employ a set of APL written interactive subroutines for simulation control. These routines allow readout and alteration of digital constants and variables, reassignment of D/A and A/D channels, performance of parameter variation runs, and printout of digital data (Ref. 14).

APPENDIX D
INTERACTIVE SUBROUTINES

1. INTRODUCTION

A set of generalized user communication subroutines has been added to the HVHP to enhance its operation by engineers. A subset of these routines directly aimed at the engineering user expedite the simulation functions of changing parameters, selecting variables for output, performing parametric runs, and general simulation control. Another subset, directed toward the simulation designer, allows tasks such as reassigning and rescaling analog-to-digital and digital-to-analog converters, printing the current values of all digital variables, and printing selected members of arrays. The use of these routines has allowed easy configuration of the HVHP to perform the vehicle handling test procedures (VHTP) and to calculate the vehicle comparison variables (CV).

2. SUBROUTINE USE

All simulation control occurs at the hybrid operator's station which consists of a telecommunications device (teletypewriter or a CRT with keyboard). Once the simulation is active, the user controls simulation activity with input responses to the OPTION cue. Each input selects an interactive routine. Once a routine has been selected, the user is queried for information necessary to perform the task of the selected routine. When the routine is completed, the readiness of the simulation for the next routine is indicated by the reappearance of the OPTION cue. Table I lists the names of the currently available interactive subroutines.

TABLE I

INTERACTIVE SUBROUTINE LIST

X (Execute Single Simulation Run)

XM (Execute Multi-run Series)

IC (Initialize Simulation)

F (Read or Alter Real Variables)

I (Read or Alter Integer Variables)

DACA (Alter DAC Array)

ADCA (Alter ADC Array)

MULTI (Setup Multiple Runs)

TEST (Test Runs)

MES (Send Message to Line Printer)

TABLE (Setup End-of-Run Output)

TRACK (Setup during Run Data Collection)

LA (List Array Values)

REMOVE (Suspend Output)

T+D (Output Timed and Date)

STD (Standard Output)

DUMP (Output All Variables)

DACL (List DAC Array)

ADCL (List ADC Array)

TERM (Terminate Program)

In general the routines either alter simulation data, provide simulation control, or provide for output of simulation data. For output, the information may be directed to the hybrid operators station (T), the system line printer (L) or both (B). Also, the output can be specified as immediate (XEQ), at the end of a single run execution (S), or at the end of each run in a multiple-run execution (M). These output selections and their codes are shown in Table II.

Table II
Data Output Selections

Unit	Mode
T = CRT	S = Single Runs Only
L = System Line Printer	M = Multi-runs Only
B = Both T and L	A = Both S and M
	XEQ = Immediately

3. INTERACTIVE VARIABLES

To be effective, the routines must access, by name, the Fortran variables within a simulation. The variables of interest, termed interactive variables, need only appear in a Fortran named COMMON to be accessed. Once selected, a variable can be given any number of aliases. The alias capability is particularly important when an interactive variable is an array member. For instance, the current value of input brake line pressure, which is stored in element 121 of the PARAM array, has been given the alias PFL. Also, the PARAM array has been given the shorter alias PRM. A maximum of 400 interactive variables can be selected. However, it is important to note that the PARAM array, which has 295 elements, uses only one interactive variable allocation. Nearly all

variables which are associated with wheel computation (side force, FSI; normal force, FRI; ground patch velocity, CVI; etc.) are addressable as arrays and use only one interactive variable allocation. Currently, 300 interactive names have been used which permit the interrogation or alteration of more than 900 Fortran variables.

Each subroutine is discussed, including all required inputs, and actual user examples are presented. In the example, **** indicates user input. The remainder is computer output. Although it is not presented, the routines have extensive error handling facilities which prompt a user when errors are made.

4. SUBROUTINE DESCRIPTIONS

X (Execute Single Run)

Purpose - Perform a single simulation run. The simulation is automatically initialized (IC) and a run performed.

OPTION when the run is completed and all output has been printed.

Example -

```
OPTION
****  X
JUNE       20  1974
TIME   10.18:17.09
RUN    5 HAS STARTED
OUTPUT BELOW
 AXAV=    0.0    DECL TIME=    0.000 AVCUR=    0.118 BTDMAX=    0.023 BTMAX=    0.007 DELBT=    0.008
AYMAX=    0.154 PHIMAX=    1.502 RMAX=    0.085 LANE CHNG DEL=    0.0   DELPSI=   0.0    MAX STEER=  27.927
FTRQMAX=    0.0    RTRQMAX=    0.0

OPTION
```

XM (Execute Multi-run Series)

Purpose - Perform a series of parametric runs. The simulation is automatically initialized (IC) prior to each run in the series being performed.

Input Requested - None. Control is returned to OPTION when the run series is completed and all output has been printed.

Example -

```
OPTION
****   XM
JUNE        20   1974
TIME  10:24: 7.18
RUN  10 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(    1) BETAMX(    1) BETDMX(    1) CUVRAT(    1)
  1     10         28.0         0.674E-02     0.237E-01      0.111
  2     11         56.0         0.141E-01     0.465E-01      0.209
  3     12         84.0         0.254E-01     0.655E-01      0.306
  4     13         112.         0.416E-01     0.903E-01      0.394
```

IC (Initialize Simulation, DO NOT Execute)

Purpose - Resets variables back to their initial conditions. Sets potentiometers and DAC's, then returns control to OPTION.

Internal Input Requested - None.

Example -

```
OPTION
****   IC
OPTION
```

F (Alter or Read Real Variables)

Purpose - Read current values of parameters, initial conditions, and variables which are declared "REAL" to Fortran. Alter current values of "REAL" parameters and initial conditions.

Input Requested - Interactive variable only for readout, interactive variable followed by new value for altering data.

Variation - Array Readout: (a) Interactive variable followed by range of array to be output, (b) interactive variable followed by the letters AM, allows addressing array elements by number.

Examples -

```
OPTION
****  F
ENTER
****  VHTPNO
  0.0
****  VHTPNO 5.
****  FRI 1 4
   1==>  1073.          2==>  1073.          3==>  887.7          4==>  887.7
****  PRM 285 287
 285==>  3.900        286==> 0.0           287==>  1.000
****  PRM 1 23
   1==>  12.33          2==> 0.5100          3==> 0.8200          4==>  11.30
   5==>  11.30          6==>  49.30          7==>  68.70          8==>  59.80
   9==>  61.80         10==>  47.00         11==>  3758.         12==> 0.2305E 05
  13==> 0.2333E 05     14==>  530.0         15==>  550.0         16==> 0.0
  17==> 0.4040E 05     18==>  40.00         19==>  105.0         20==>  2.000
  21==> -2.400         22==>  2.100         23==> 0.0
```

```
****  FRI AM
****  1
   1073.
****  2
   1073.
****  3
   887.7
****  4
   887.7
****  PRM AM
****  285
   3.900
****  285 4.4
****  285
   4.400
****
```

I (Alter or Read Integer Variables)

Purpose - Read current values of parameters, initial conditions and variables which are declared INTEGER to Fortran. Alter current values of INTEGER parameters and initial conditions.

Input Requested - Interactive variable only for readout, interactive variable followed by new value for altering data.

Example -

```
OPTION
****  I
ENTER
****  IPOT
     283
****
```

DACA (Alter DAC Array)

Purpose - To change DAC variable assignment and/or scaling.

Inputs Requested

1) "ENTER DAC NUM OR NAME"

(a) Purpose - To select DAC to be altered.

(b) Input Requested - The name of any interactive variable that is assigned to a DAC or a number 1 - 48.

2) "ENTER NAME"

(a) Purpose - To reassign a new variable to the DAC.

(b) Input Requested - Any interactive variable. Depressing the carriage return will retain the old assignment.

3) "SCALE FACTOR"

(a) Purpose - To enter scale factor.

(b) Input Requested - Any number.

Example -

```
OPTION
****  DACA
TO RETURN TO OPTIONS  HIT CR
ENTER DAC ARRAY NUM OR NAME
****  1
DACO( 1) = IOUT..(   1) /     1.0000
ENTER NAME
****  AYMAX
SCALE FACTOR
****  1.
ENTER DAC ARRAY NUM OR NAME
****
OPTION
```

ADCA (Alter ADC Array)

Identical to DAC routine with the exception that the interactive variable is assigned to an ADC not a DAC and the number must be 1 - 28

Example -

```
OPTION
****  ADCA
TO RETURN TO OPTIONS  HIT CR
ENTER ADC ARRAY NUM OR NAME
****  20
QUAN2.(   1) = ADCO(20) *     1.0000
ENTER NAME
****  SLIPI(2)
SCALE FACTOR
****  1.
ENTER ADC ARRAY NUM OR NAME
****
```

MULTI (Multiple Runs)

Purpose - To automatically execute a series of runs. Parameters (interactive variables) may be incremented from run to run by this routine. Parameters retain

their incremented value at the end of the multiple run.

Inputs Requested -

1) "NUMBER OF LOOPS, VARS"

   (a) Purpose - To specify the total number of runs to be made and the number of interactive variables to be incremented.

   (b) Input Requested - LOOPS, a number less than 100; VARS, a number less than 50.

2) "VAR"

   (a) Purpose - To specify the interactive variables to be incremented. The variables are incremented at the end of each run in the multi-loop. If a zero is entered, control is returned to OPTION.

   (b) Input Requested - Any interactive variable.

3) "LOOP, VAL, INC"

   (a) Purpose - To specify the run number, initial value, and increment per run.

   (b) Input Requested - A value can be specified for each run with a zero increment or a series can be setup by the input of an increment. The incrementing is halted at

each new LOOP input or when runs equal to the total number of LOOPS have completed.

Example -

```
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  12 2
VAR
****  STR4
LOOP,VAL,INC
****  1 28. 28.
****  7 28. 28.
****
VAR
****  UIN
LOOP,VAL,INC
****  1 50. 0.
****  7 60.
****  7 60. 0.
****
OPTION
```

TEST (Test Run or Abend)

Purpose - To run the problem without real-time service or produce an abnormal termination, thus giving a program dump.

Input Requested

1) "ENTER: RTIME, NO RTIME, ABEND"

(a) Purpose - To indicate that a command is desired.

(b) Input Requested - One of three commands:

(1) No RTIME - This will remove the real-time calls.

(2) RTIME - This will replace the real-time calls.

(3) ABEND - Will produce a program dump.

Example -

```
OPTION
****  TEST
ENTER: RTIME,NO RTIME,ABEND
****  RTIME
```

MES (Send Message to Line Printer)

Purpose - To send a message to the line printer that will document analog programming changes (experimental or permanent), indicate the state of analog computer, or log simulation information.

Inputs Requested - A message that is less than 80 characters long per line.

Example -

```
OPTION
****  MES
TO RETURN TO OPTIONS HIT CR TWICE
****  THIS OPTION IS USEFUL FOR
****  DOCUMENTING SIMULATION RUNNING
****  AND KEEPING SIMULATION NOTES
****
```

TABLE (Tabular Output)

Purpose - To output data for a series of runs in a tabular form. Designed for use in the multi-run cases. This routine automatically is called whenever a multi-run case is in affect, unless it is deselected.

Input Requested - Up to nine interactive variables.

Example -

```
OPTION
****  TABLE
UNIT,MODE
****  T M
ENTER UP TO 9 NAMES
****  STR4 BETAMX BETDMX CUVRAT
****
```

TRACK (Track Real-Time Variables)

Purpose - To collect and output simulation data as a function of time.

Input Requested -

"TIME ON, OFF, STEP, VARIABLES"

1) TIME ON

(a) Purpose - To state the time in seconds that the routine will turn on.

(b) Input Requested - Any positive number.

2) TIME OFF

(a) Purpose - To state the time in seconds that the routine will turn off.

(b) Input Requested - Any positive number $\geq$ TIME ON.

3) TIME STEP

(a) Purpose - To state the time between samples. If this sample interval is too small, the program will automatically compensate for it.

(b) Input Requested - Any positive number.

4) VARIABLES

(a) Purpose - To enter the interactive variables to be tracked. Entering the word Retain will retain the previous variable list.

(b) Input Requested - Up to 50 variables.

Example -

```
OPTION
****  TRACK
UNIT,MODE
****  T A
ENTER TIME ON,OFF,STEP
****  .5 1.1 .1
TYPE RETAIN OR ENTER NEW ARRAY
****  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****

 TIME   PSIDT.(   1)  PHIDT.(    1)  PHI...(    1)  ZIMX..(    1)  ZIMX..(   3)
 0.50   0.43077        0.77597E-02   -0.11728         0.29986E-01   0.10125
 0.60   0.35703        0.29683       -0.10414         0.29986E-01   0.10125
 0.70   0.28586        0.49151       -0.59047E-01     0.29986E-01   0.10125
 0.80   0.28740        0.32454       -0.16426E-01     0.29986E-01   0.10125
 0.90   0.30123        0.14344E-02   -0.12279E-03     0.29986E-01   0.10125
 1.00   0.28316       -0.14820       -0.90558E-02     0.29986E-01   0.10125
 1.10   0.29048       -0.38197       -0.30314E-01     0.29986E-01   0.10125
OPTION
```

LA (List Array Values)

Purpose - To output the values of variables which are array members.

Input Requested - Any Interactive Variable which is an array followed by the range of the array desired.

Example -

```
OPTION
****  LA
UNIT,MODE
****  T XER
ENTER  NAME,INDEX1,INDEX2
****  FRI 1 4
****  FS1 1 4
****  PRM 11 14
****  PARAM 11 14
****  .
FRI.....
   1==)  1073.        2==)  1073.         3==)  887.7         4==)  887.7
FSI.....
   1==) -10.51        2==)  10.51         3==) 0.0            4==) 0.0
PRM.....
  11==)  3832.       12==) 0.2400E 05    13==) 0.2431E 05    14==)  530.0
PARAM...
  11==)  3832.       12==) 0.2400E 05    13==) 0.2431E 05    14==)  530.0
```

REMOVE (Suspend Output)

Purpose - To cancel the execution of a selected Interactive Subroutine.

Input Requested - Any Interactive Subroutine name.

Example -

```
OPTION
****  REMOVE
WHAT
****  TRACK
```

The following routines have no inputs. Output is directed to the CRT.

T+D (Time + Date)

Purpose - To display the time and date.

Example -

```
OPTION
****  T+D
UNIT/MODE
****  T XEQ
JUNE      21  1974
TIME  14:30:40.67
```

STD (Standard Output)

Purpose - Select standard end of run data.

Example -

```
OPTION
****  STD
UNIT/MODE
****  I XEQ
 AXAV=    0.0   DECL TIME=    0.0    AVCUR=    0.0    BTDMAX=    0.0    BTMAX=    0.0    DELBT=    0.0
AYMAX=    0.000 PHIMAX=    0.0    RMAX=    0.0    LANE CHNG DEL=    0.0    DELPSI=    0.0    MAX STEER=    0.0
FTRQMAX=    0.0   RTRQMAX=    0.0
```

DUMP (Dump Data List)

Purpose - To display the value of each interactive variable at the time the dump is selected to execute.

Example -

```
OPTION
****  DUMP
UNIT/MODE
****  I XEQ

ABBTV.= 0.0          DEL1DT= 0.0          OTM...=  63.28       S3P...= -38.00
ABI...= 0.1962E-01   DEL2DA= 0.0          P.....= 0.0          S4P...= -38.00
AFA...=  1.000       DEL2DT= 0.0          PARAM.=  8.430       TBCR3.=  2.923
AIXBR.=  3928.       DEL3DA= 0.0          PBF...= 0.0          TBCR4.=  2.923
AIXF..=  169.8       DEL3DT= 0.0          PBR...= 0.0          TBSR3.=  1.038
AIXZBR=  177.5       DLIS..= -.8000       PHF...= -.3097E-03   TBSR4.= 0.9047
AIXZF.= -352.5       DLYTB.= -.2453E-54   PFI...=  1000.       TERDAC= -.5388E 09
AIYBR.= 0.2322E 05   DSWMAX= 0.0          PHI...= 0.0          TF02..=  29.90
AIYF..=  169.8       DT....= 0.1000E-01   PHICGI= -.5630E 02   THE...= -.1215E-02
AIZBR.= 0.2944E 05   D1....= 0.0          PHIDAX= 0.0          THEDT.= 0.0
AKK1..=  1.000       D2....= -1.299       PHIDT.= 0.0          THEFNT= 0.7500
AKE2..=  1.000       D3....= 0.0          PHIFNI= -.3800       THEO..= -.1215E-02
ALFI..= -.2262E 08   D4....= 0.1146E-68   PHII..= -.6405E 02   THERR.= 0.0
ALIO..= -46.06       ETAL..= -.1133E-05   PHIMAX= 0.0          THRD..= 0.3333
AMT1..=  25.85       ETAX..= -.2176E-03   PHIO..= 0.0          THS1..= 0.1309E-01
AMT2..= -25.85       EXTAB.= -.1278E-56   PHIRD.= 0.0          THS2..= 0.1309E-01
AMUI..= 0.9657       E1....= 0.1156E 09   PHIRDA= 0.0          TIMBMP= 0.0
AM1I..=  5.018       E2....= -.4480E 06   PHIRR.= 0.0          TIMDEC= 0.0
AM2I..= -.2466       E3....= 0.1252E 06   PO....= 0.0          TIME..= 0.0
ANGNL.= 0.1180E 09   FBS1..= 0.0          PRM...=  8.430       TIME10= 0.0
ANGNLO= 0.8392E-04   FBS2..= 0.0          PSI...= 0.0          TIME25= 0.0
ANTI1.=  1.734       FBS3..= 0.0          PSIDT.= 0.0          TIMIN5= 0.0
ANTI2.=  1.734       FBS4..= 0.0          PSIFNT= -.2700       TMAX1.= 0.9942E 28
ANTI3.= -.1425       FCI...= 0.0          PSII..= -.1558E-02   TMAX2.= 0.1991E 06
ANTI4.= -.1425       FCIMAX=  892.9       PSIMAX= 0.0          TMAX3.= -.4879E-49
AF1...= 0.1381       FI....=  1.000       PSIO..= 0.0          TMP...= 0.0
AF2...= 0.1381       FOTM..= -1.218       PSIOUT= 0.0          TQBF..= 0.0
```

```
AP3...= -.1425      FRI...=  1047.      PSIRR.= 0.0          TQBR..= 0.0
AP4...= -.1425      FRIBR.=  1047.      PSI3S.= 0.0          TQFMAX= 0.0
ARPS1.=  56.79      FSI...= -19.70      PSI4S.= 0.0          TQRMAX= 0.0
ARPS2.=  56.97      FXL1..= 0.0         PSI5..= 0.0          TRCR3.=  1.315
AR1...=  1.596      FXL2..= 0.0         PSR3..= 0.0          TRCR4.=  1.315
AR2...=  1.596      FXUI..= -1.302      PSR4..= 0.0          TRO2..=  30.90
AR3...= 0.0         FYUI..= -19.70      Q.....= 0.0          TRSR3.= 0.4669
AR4...= 0.0         G.....=  386.4      QDT...= 0.5060E-01   TRSR4.= 0.4069
AXAVE.= 0.0         GAMF..= 0.0         QO....= 0.0          TSO2..=  23.50
AXI...= 0.0         GAM1..= -31.19      QUAN1.= 0.0          TSTEP.= 0.1000E-01
AYMAX.= 0.1133E-05  GAM2..=  15.03      QUAN2.= 0.0          TWN7..= 0.3704E-01
A1....=  1.540      GAM3..=  15.03      QUAN3.= 0.0          U.....=  880.0
A12...= -1543.      GBI...= -.1949E-01  QUAN4.= 0.0          UDT...= -.8422E-01
A2....=  1545.      GETDL.= 0.0         R.....= 0.0          UGI...=  880.0
A2T...=  1900.      GI....= -.1882E-01  RDT...= -.2380E-05   UGIP..=  880.0
BAMI..= 0.2221E-02  GP1...= 0.2864E 06  RMAX..= 0.0          UI....=  880.0
BETAI.= 0.1558E-02  GP2...=  2202.      RMI...=  1011.       UIN...=  50.00
BETAMX= 0.0         GR1...=  2202.      RO....= 0.0          UO....=  880.0
BETDMX= 0.0         GR2...= 0.3811E 05  ROTM..= 0.0          UOUT..=  880.0
BETIBR= -.1962E-01  GV1...= 0.4480E 06  ROUT..= 0.0          UOI...= 0.6966
BETIP.= 0.6625E-03  GV2...= 0.1252E 06  RTAB..= -.8457E-53   U1I...= 0.6500
BMPN..= 0.0         IAX...= 0.5148E-84  RWZI..= 0.7219       U1P...= 0.0
BMPS..= 0.0         IDACK.= 0.0         RZF...=  24.50       U2P...= 0.0
BRKOFF=  1.020      IENDR.= -14.24      RZR...=  24.50       U3P...= 0.0
BRKON.= 0.5200      IERDAC= -14.24      SALTQ.= 0.0          U4P...= 0.0
BSLOPE= 0.5000E-01  IN....= -.2014E-02  SAM1..= 0.1272       V.....= 0.0
BTV...= 0.0         INA...= 0.2523E 09  SCR3..= 0.3551       VDT...= -.4844E-03
BTVDT.= -.4975E-06  IOR...= 0.8236E-83  SCR4..= 0.3095       VGI...= 0.0
CA20..= 0.6842E 07  IOUT..= 0.7892E-04  SFIN..= -100.0       VHTPNO=  6.000
CA23..=  3293.      IOUTA.= 0.2031E 38  SFOUT.=  1.000       VI....= 0.0
CIP...=  4105.      IPOT..= 0.1524E-81  SFXU..= -4.643       VO....= 0.0
CIVP..=  2046.      IPOTAD= 0.1524E-81  SFYU..= 0.0          VOUT..= 0.0
COSPSI=  1.000      IPRT..= 0.0         SINPSI= -.1558E-02   W.....= 0.0
CPSR3.=  1.000      ISW1..= 0.0         SLIPI.= 0.0          WCTH1.= -.7869
CPSR4.=  1.000      ISW7..= 0.0         SM....=  9.760       WCTH2.= -.9782
CURTBP= 0.0         ITMP..= 0.7892E-04  SN....= 0.0          WDT...=  18.51
CURVAV= 0.0         IVHTP.= 0.3089E-83  SNI...=  1.000       WI....= 0.0
CUVRAT= 0.0         JJTIME= 0.0         SNPHTU= -1.218       WO....= 0.0
CVI...=  50.00      JUMP..= 0.0         SNPSIU= 0.0          WSTH1.= 0.6163
DACO..= 0.7892E-04  MUP...= 0.8563      SNTHEU=  1166.       WSTH2.= 0.2056
DEL...= 0.0         NCAM..= 0.5432E 09  SPSR3.= 0.3551       X.....= 0.0
DELBET= 0.0         NCAS..= -.7418E-67  SPSR4.= 0.3095       XDT...=  880.0
DELFW1= 0.0         NFA...= 0.5148E-83  STR1..= 0.0          XO....= 0.0
DELFW2= 0.0         NTF...= 0.1030E-83  STR2..= 0.0          Y.....= 0.0
DELPHI= -.7662E 55  NTR...= 0.1030E-83  STR3..= 0.0          YDT...= 0.0
DELPSI= 0.0         N1....= 0.1519E-81  STR4..= 0.0          YO....= 0.0
DELSTR= 0.0         N2....= 0.6126E-82  STR5..=  223.4       Z.....= -23.84
DELTA.= 0.1118E 10  ONEOA.= -.6480E-03  STR6..=  223.4       ZDT...=  1.069
DELTHE= -.1079E-49  ONEOD.= 0.8947E-09  S1P...= -40.00       ZI....= -12.48
DEL1DA= 0.0         ONER..= -.5653E-09  S2P...= -40.00       ZIMX..= 0.7219
OPTION
```

DACL (DAC List)

Purpose - To list the DAC assignments and scale factors.

Example -

```
OPTION
****  DACL
UNIT/MODE
****  T XEQ
DACO( 1) = IOUT..(   1)/    1.0000
DACO( 2) = IOUT..(   2)/    1.0000
DACO( 3) = IOUT..(   3)/    1.0000
DACO( 4) = IOUT..(   4)/    1.0000
DACO( 5) = IOUT..(   5)/    1.0000
DACO( 6) = IOUT..(   6)/    1.0000
DACO( 7) = IOUT..(   7)/    1.0000
DACO( 8) = IOUT..(   8)/    1.0000
DACO( 9) = IOUT..(   9)/    1.0000
DACO(10) = IOUT..(  10)/    1.0000
DACO(11) = IOUT..(  11)/    1.0000
DACO(12) = IOUT..(  12)/    1.0000
DACO(13) = IOUT..(  13)/    1.0000
DACO(14) = IOUT..(  14)/    1.0000
DACO(15) = IOUT..(  15)/    1.0000
DACO(16) = IOUT..(  16)/    1.0000
DACO(17) = IOUT..(  17)/    1.0000
DACO(18) = IOUT..(  18)/    1.0000
DACO(19) = IOUT..(  19)/    1.0000
DACO(20) = IOUT..(  20)/    1.0000
DACO(21) = IOUT..(  32)/    1.0000
DACO(22) = IOUT..(  31)/    1.0000
DACO(23) = IOUT..(  23)/    1.0000
DACO(24) = IOUT..(  29)/    1.0000
DACO(25) = IOUT..(  25)/    1.0000
DACO(26) = IOUT..(  26)/    1.0000
DACO(27) = IOUT..(  27)/    1.0000
DACO(28) = IOUT..(  28)/    1.0000
DACO(29) = IOUT..(  24)/    1.0000
DACO(30) = IOUT..(  30)/    1.0000
DACO(31) = IOUT..(  22)/    1.0000
DACO(32) = IOUT..(  21)/    1.0000
DACO(33) = IOUT..(  33)/    1.0000
DACO(34) = IOUT..(  34)/    1.0000
DACO(35) = IOUT..(  35)/    1.0000
DACO(36) = IOUT..(  36)/    1.0000
DACO(37) = IOUT..(  37)/    1.0000
DACO(38) = ANTI1.(   1)/    10000.
DACO(39) = ANTI2.(   1)/    10000.
DACO(40) = ANTI3.(   1)/    10000.
DACO(41) = ANTI4.(   1)/    10000.
DACO(42) = ETAX..(   1)/    1.4000
DACO(43) = ETAL..(   1)/    1.4000
DACO(44) = ROUT..(   1)/    1.0000
DACO(45) = UOUT..(   1)/    1200.0
DACO(46) = VOUT..(   1)/    1200.0
DACO(47) = BTV...(   1)/    3.1400
DACO(48) = ONER..(   1)/  0.41700E-02
```

ADCL (ADC List)

Purpose - To list the ADC assignment and scale factors.

Example -

```
OPTION
****  ADCL
UNIT,MODE
****  T XEQ
DEL1DT(    1) = ADCO( 1)*     -100.00
DEL2DT(    1) = ADCO( 2)*     -100.00
DEL3DT(    1) = ADCO( 3)*     -100.00
DEL1DA(    1) = ADCO( 4)*      10.000
DEL2DA(    1) = ADCO( 5)*      10.000
DEL3DA(    1) = ADCO( 6)*      10.000
PHIRD.(    1) = ADCO( 7)*      1.0000
PHIRDA(    1) = ADCO( 8)*     0.25000
DELFW1(    1) = ADCO( 9)*     0.50000
DELFW2(    1) = ADCO(10)*     0.50000
U1P...(    1) = ADCO(11)*      2.0000
U2P...(    1) = ADCO(12)*      2.0000
U3P...(    1) = ADCO(13)*      2.0000
U4P...(    1) = ADCO(14)*      2.0000
S1P...(    1) = ADCO(15)*      1000.0
S2P...(    1) = ADCO(16)*      1000.0
S3P...(    1) = ADCO(17)*      1000.0
S4P...(    1) = ADCO(18)*      1000.0
QUAN1.(    1) = ADCO(19)*      1.0000
QUAN2.(    1) = ADCO(20)*      1.0000
QUAN3.(    1) = ADCO(21)*      1.0000
QUAN4.(    1) = ADCO(22)*      1.0000
ARPS1.(    1) = ADCO(23)*      100.00
ARPS2.(    1) = ADCO(24)*      100.00
WSTH1.(    1) = ADCO(25)*      1.0000
WCTH1.(    1) = ADCO(26)*      1.0000
WSTH2.(    1) = ADCO(27)*      1.0000
WCTH2.(    1) = ADCO(28)*      1.0000
OPTION
```

TERM (Terminate Program)

Purpose - To terminate program.

Example -

```
OPTION
****  TERM
JUNE        21   1974
TIME   17:  5:38.72
PROGRAM TERMINATED
```

If the OPTION cue detects an error or an error is forced by user, the active Subroutines can be determined by the input of a question mark (?).

Example -

```
OPTION
****
ERROR
****   ?
OPTION NOT FOUND
TO XEQ. PROGRAM          TYPE X
TO TERMINATE PROGRAM     TYPE TERM
FOR MULTIPLE RUNS        TYPE MULTI
FOR TEST RUN OR ABEND    TYPE TEST
TO ALTER DAC ARRAY       TYPE DACA
TO ALTER ADC ARRAY       TYPE ADCA
TO SET IC ONLY           TYPE IC
TO SEND MESSAGE TO LP    TYPE MES
FOR TIME AND DATE                    TYPE T+D
TO DUMP DATA LIST                    TYPE DUMP
FOR STANDARD OUTPUT                  TYPE STD
TO TRACK REAL TIME VARIABLES         TYPE TRACK
FOR TABULAR OUTPUT                   TYPE TABLE
TO LIST DAC ARRAY                    TYPE DACL
TO LIST ADC ARRAY                    TYPE ADCL
```

APPENDIX E

SIMULATION DATA

1. PRESENTED HERE IS THE LISTING OF THE INPUT DATA DECKS

```
VEHICLE MODEL - 1971 DODGE CORONET
-0.38       .1061661  .1684393  .01604185 -.00579372-.00220835 0.0
0.75        0.0       0.0       0.0       0.0       0.0       0.0        MAIN9110
-0.27       -.2416662 -.00944941.01291661 -.00089631-.00125    0.0
0.0         0.0       0.0       0.0       0.0       0.0       0.0
0.0         0.0       0.0       0.0       0.0       0.0       0.0        MAIN9140
0.0         0.0       0.0       0.0       0.0       0.0       0.0        MAIN9150
0.          0.              TABLE I - FRONT BRAKE TORQUE FUNCTION
1000.       20640.
99999.                                                                   MAIN9190
0.          0.              TABLE II - REAR BRAKE TORQUE FUNCTION
1000.       20640.
99999.                                                                   MAIN9230
0.0          1.00      TABLE III- SIDE FORCE SHAPING FUNCTION
0.05         0.99
0.1          0.97
0.15         0.93
0.2          0.86
0.30         0.72
0.4          0.56
0.6          0.34
0.8          0.25
1.0          0.18
99999.                                                                   MAIN9410
 T+D      DUMP     STD      TESTO    LA                                  MAIN9470
 RESET    TRACK    TABLE    PLOT     DACL                                MAIN9480
 ADCL     ZZZZZZZZSTAT      PC       TM                                  MAIN9490
 CHANGE   READ              CONTROL                                      MAIN9500
 I        TEST     X        RE-STR   DACA                                MAIN9510
 ADCA     OUTPUT   F        MULTI    TERM                                MAIN9520
 MES      IC         ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                 MAIN9530
  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)

 PFL AXAVF TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  8.43
002  0.51
003  0.82
004  11.3
005  11.3
006  49.3
007  68.7
008  59.8
009  61.8
010  47.0
011  3758.
012  23047.
013  23327.
014  530.
015  550.
016  0.                                                                  MAIN9730
017  40400.
018  40.
 19  105.
```

```
021 -2.4
022  2.1
023  0.                                                              MAIN9800
024  -5100.
025  38.
 26  120.
027  2.0
028 -4.4
029  3.6
030  0.020
031  13.2
032  0.0
033   0.75                                                           MAIN9900
034  2701.
035  10.14
036  2533.
037  1.30
038  4591.
039  0.0
040  1.27
041  8000.
042  14.2
043  1.8
044  5.6
045  2.7
046  7.2
047  6.4
 48  0.0
049  9.4
050  9.4
051  0.7
052  2.71
 53  0.0
 54  0.0
055 -0.66
056  4.59
057 -4.59
058 -.1309
059  .1309
060  1.0
061  0.0
062  0.0                                                             MAINC190
063                                                                  MAINC20C
064                                                                  MAIN0210
065                                                                  MAIN0220
066  40.
067                                                                  MAIN0240
068                                                                  MAIN0250
069                                                                  MAIN0260
070                                                                  MAIN0270
071
072                                                                  MAIN029C
073                                                                  MAIN0300
074                                                                  MAIN0310
075 .010                                                             MAINC320
 76  5.0
077  1450.
078  1450.
079  1450.
```

```
080  1450.
081
082
083
084
085  -.00033
086  0.0
087  1.228
088  .0000000759                                   MAIN0460
089                                                MAIN0470
090                                                MAIN0480
091   0.0
092  -0.8
093 -.68                                           MAIN0510
094                                                MAIN0520
095                                                MAIN0530
096                                                MAIN0540
097                                                MAIN0550
098                                                MAIN0560
099                                                MAIN0570
100                                                MAIN0580
101                                                MAIN0590
102                                                MAIN0600
103                                                MAIN0610
104                                                MAIN0620
105                                                MAIN0630
106                                                MAIN0640
107   1.0                                          MAIN0650
108                                                MAIN2560
109 0.
110  0.0
111  0.0
112  0.0                                           MAIN0700
113  1.
114  25.
115  1.0
116  0.5
117  3.
118  3.                                            MAIN0760
119                                                MAIN0770
120
121  300.                                          MAIN0790
122                                                MAIN0800
123                                                MAIN0810
124                                                MAIN0820
125                                                MAIN0830
126                                                MAIN0840
127
128  3.0                                           MAIN0860
129 0.
130  0.06
131  16.0
132  55900.
133  55900.
134  6.62
135  6.62
136  11.0
137  54.
138  5.20
139  0.45
```

```
-0.45
 0.                                                              MAIN0980
 0.                                                              MAIN0990
                                                                 MAIN1000
                                                                 MAIN1010
 0.0
 0.0
                                                                 MAIN1040
                                                                 MAIN1050
                                                                 MAIN1060
                                                                 MAIN1070
                                                                 MAIN1080
                                                                 MAIN1090
                                                                 MAIN1100
                                                                 MAIN1110
                                                                 MAIN1120
                                                                 MAIN1130
                                                                 MAIN1140
                                                                 MAIN1150
                                                                 MAIN1160
                                                                 MAIN1170
                                                                 MAIN1180
                                                                 MAIN1190
                                                                 MAIN1200
                                                                 MAIN1210
                                                                 MAIN1220
                                                                 MAIN1230
                                                                 MAIN1240
                                                                 MAIN1250
 73.
 73.
 73.
2.                                                               MAIN1290
                                                                 MAIN1300
                                                                 MAIN1310
0.25                                                             MAIN1320
                                                                 MAIN1330
                                                                 MAIN1340
                                                                 MAIN1350
1.                                                               MAIN1360
3.                                                               MAIN1370
 1.                                                              MAIN1380
 0.17
 0.17
 0.17
 0.17
                                                                 MAIN1430
                                                                 MAIN1440
                                                                 MAIN1450
 0.0
                                                                 MAIN1470
                                                                 MAIN1480
 1.                                                              MAIN1490
                                                                 MAIN1500
                                                                 MAIN1510
                                                                 MAIN1520
 0.
 0.
```

```
200  1.5                                   MAIN1570
201
202  0.94
203  -.00008
204  0.94
205  -.00008
206  0.65
207  0.65
208  0.
209  0.
210  0.                                    MAIN1680
211  0.0
212  0.
213  0.                                    MAIN1710
214  0.
215  0.
216  0.
217  0.
218  0.
219  0.
220  0.
221  0.
222  0.
223  0.
224  0.
225  0.
226  0.
227  0.
228  0.
229  0.
230  0.
231  400.
232  400.
233  0.
234  105.
235  105.
236  120.
237  120.
238  1.
239  1.
240  .67
241  .67
242  -.0000393
243  -.0000332
244  .00000175
245  -.00033
246  0.0
247  1.228
248  .0000000759
249  -.00318
250  .00349
251  1.404
252  -.00318
253  .00349
254  1.404
255  0.0
256  -.0015
257  -.005244
258  -5.592
259  0.0
```

```
260   -.0015
261   -.005244
262   -5.592
263   -0.13
264   -.03
265   .0
266   0.15
267   .015
268   .0
269   0.089
270   .01
271   .0
272   0.0
273   .0
274   .0
275   0.0
276   0.0
277   0.                                                        MAIN2340
278   0.                                                        MAIN2350
279   0.                                                        MAIN2360
280   0.                                                        MAIN2370
281   1.                                                        MAIN2380
282   1.                                                        MAIN2390
283   0.                                                        MAIN2400
284   2.7
285   3.9
286   0.0
287   1.
288   0.                                                        MAIN2450
289   0.                                                        MAIN2460
290   0.75                                                      MAIN2470
291   2701.
292   10.14
293   2533.
294   1.30
295   4591.
001   8.82
004   10.9
005   10.8
006   50.5
007   67.5
011   3832.
012   24003.
013   24311.
092   -1.1
093  -1.08
304                                                             MAIN2660
IOUT(01)  1.                                                    MAIN2670
IOUT(02)  1.                                                    MAIN2680
IOUT(03)  1.                                                    MAIN2690
IOUT(04)  1.                                                    MAIN2700
IOUT(05)  1.                                                    MAIN2710
IOUT(06)  1.                                                    MAIN2720
IOUT(07)  1.                                                    MAIN2730
IOUT(08)  1.                                                    MAIN2740
IOUT(09)  1.                                                    MAIN2750
IOUT(10)  1.                                                    MAIN2760
IOUT(11)  1.                                                    MAIN2770
IOUT(12)  1.                                                    MAIN2780
IOUT(13)  1.                                                    MAIN2790
```

```
IOUT(14)  1.                                                  MAIN2800
IOUT(15)  1.                                                  MAIN2810
IOUT(16)  1.                                                  MAIN2820
IOUT(17)  1.                                                  MAIN2830
IOUT(18)  1.                                                  MAIN2840
IOUT(19)  1.                                                  MAIN2850
IOUT(20)  1.                                                  MAIN2860
IOUT(32)  1.                                                  MAIN2980
IOUT(31)  1.                                                  MAIN2970
IOUT(23)  1.                                                  MAIN2890
IOUT(29)  1.                                                  MAIN2950
IOUT(25)  1.                                                  MAIN2910
IOUT(26)  1.                                                  MAIN2920
IOUT(27)  1.                                                  MAIN2930
IOUT(28)  1.                                                  MAIN2940
IOUT(24)  1.                                                  MAIN2900
IOUT(30)  1.                                                  MAIN2960
IOUT(22)  1.                                                  MAIN2880
IOUT(21)  1.                                                  MAIN2870
IOUT(33)  1.                                                  MAIN2990
IOUT(34)  1.                                                  MAIN3000
IOUT(35)  1.                                                  MAIN3010
IOUT(36)  1.                                                  MAIN3020
IOUT(37)  1.                                                  MAIN3030
 ANTI1 10000.
 ANTI2 10000.
 ANTI3 10000.
 ANTI4 10000.
 ETAX 1.4
 ETAL 1.4
 ROUT  1.0
 UOUT  1200.
 VOUT  1200.
 BTV 3.14
 ONER .00417                                                  MAIN3070
   DEL1DT -100.                                               MAIN3080
   DEL2DT -100.                                               MAIN3090
   DEL3DT -100.                                               MAIN3100
   DEL1DA 10.                                                 MAIN3110
   DEL2DA 10.                                                 MAIN3120
   DEL3DA 10.                                                 MAIN3130
   PHIRD 1.                                                   MAIN3140
 PHIRDA 0.25                                                  MAIN3150
 DELFW1 0.5                                                   MAIN3160
 DELFW2 0.5                                                   MAIN3170
 U1P 2.                                                       MAIN3180
 U2P 2.                                                       MAIN3190
 U3P 2.                                                       MAIN3200
 U4P 2.                                                       MAIN3210
  S1P 1000.                                                   MAIN3220
  S2P 1000.                                                   MAIN3230
  S3P 1000.                                                   MAIN3240
  S4P 1000.                                                   MAIN3250
  QUAN1 1.                                                    MAIN3260
  QUAN2 1.                                                    MAIN3270
  QUAN3 1.                                                    MAIN3280
  QUAN4 1.                                                    MAIN3290
  ARPS1 100.                                                  MAIN3300
  ARPS2 100.                                                  MAIN3310
  WSTH1 1.
```

```
WCTH1 1.                                                                    MAIN3320
WSTH2 1.                                                                    MAIN3330
WCTH2 1.                                                                    MAIN3340
066  40.      40.      40.      30.      40.      45.      50.
074  0.       0.       0.       30.      0.       0.       0.
076  5.       10.      10.      5.       5.5      4.       3.
112  0.       0.       0.       0.       0.       0.       0.
114  25.      0.       62.      77.      0.       0.       0.
115  1.       0.       1.       1.       1.       0.       0.
116  .5       100.     .5       .5       .4       100.     100.
117  3.       0.       3.       0.       0.       0.       0.
118  3.       0.       3.       0.       0.       0.       0.
121  300.     200.     200.     0.       0.       0.       1000.
122  0.       0.       0.       0.       0.       0.       0.
123  0.       0.       0.       0.       0.       0.       0.
124  0.       0.       0.       0.       0.       2.       1.
125  0.       0.       0.       0.       0.       0.       1.
126  0.       0.       0.       0.       0.       1.       1.
128  3.       1.       3.       4.       2.       5.       6.
192  1.       .1       .1       .1       .1       .1       .05
198  0.       0.       0.       12.      0.       0.       0.
199  0.       0.       0.       57.6     0.       0.       0.
201  0.       0.       0.       1000.    0.       0.       0.
238  1.       1.       1.       0.00     0.00     0.00     1.
239  1.       1.       1.       0.00     0.00     0.00     1.
240  .67      .67      .67      0.00     0.00     0.00     .67
241  .67      .67      .67      0.00     0.00     0.00     .67
277  0.       0.       0.       8.       0.       0.       0.
278  0.       0.       0.       0.       0.       0.       .52
279  0.       0.       0.       0.       0.       0.       1.02
./     ENDUP
```

VEHICLE MODEL - 1971 CHEVROLET BROOKWOOD STATION WAGON

```
-0.5       .3834042  .1484607  .00647286 -.00358714-.00071117 0.0
-1.0       0.0       0.0       0.0       0.0       0.0       0.0
-0.37      -.1824622 -.03434468-.0031657 .001503944.000329646 0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0                MAIN  60
0.0        0.0       0.0       0.0       0.0       0.0       0.0                MAIN  70
0.         0.        TABLE I   -FRONT BRAKE TORQUE                              MAIN  80
1000.      17000.
99999.                                                                          MAIN 110
0.         0.        TABLE II -REAR BRAKE TORQUE                                MAIN 120
1000.      17000.
99999.                                                                          MAIN 150
0.0         1.00     TABLE III- SIDE FORCE SHAPING FUNCTION
0.05        0.99
0.1         0.97
0.15        0.93
0.2         0.86
0.30        0.72
0.4         0.56
0.6         0.34
0.8         0.25
1.0         0.18
99999.                                                                          MAIN 330
 T+D      DUMP     STD      TESTO    LA                                         MAIN 390
 RESET    TRACK    TABLE    PLOT     DACL                                       MAIN 400
 ADCL     ZZZZZZZZSTAT      PC       TM                                         MAIN 410
 CHANGE   READ              CONTROL                                             MAIN 420
 I        TEST     X        RE-STR   DACA                                       MAIN 430
 ADCA     OUTPUT   F        MULTI    TERM                                       MAIN 440
 MES      IC        ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                       MAIN 450
  PSIDT PHIDT PHI ZIMX(1)  ZIMX(3)
                                                                                MAIN 480
 PFL AXAVE TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  11.2
002  0.63
003  1.03
004  11.1
005  10.9
006  65.0
007  60.0
008  63.5
009  63.5
010  45.3
011  6124.
012  41529.
013  42445.
014  1790.
015  750.
016  0.                                                                         MAIN 650
017  408000.
018  43.
 19  141.
```

```
021 -3.5
022  2.3
023  0.                                                              MAIN 720
024  -62000.
025  73.
 26  210.
027  2.0
028 -3.6
029  2.3
030  0.033
031  14.4
032  0.0
033  1.0
034  585.91
035  14.47
036  2886.
037  2.29
038  4057.
039  0.0
040  1.08
041  8000.
042  16.2
043  2.0
044  4.2
045  1.9
046  5.1
047  10.0
 48  0.0
049  14.8
050  14.8
051  0.7
052  3.08
 53  0.0
 54  0.0
055  0.16
056  5.25
057 -5.25
058 -.1745
059  .1745
060   1.0
061  0.0
062  0.0                                                             MAIN1110
063                                                                   MAIN1120
064                                                                   MAIN1130
065                                                                   MAIN1140
066  40.
067                                                                   MAIN1160
068                                                                   MAIN1170
069                                                                   MAIN1180
070                                                                   MAIN1190
071  0.0
072                                                                   MAIN1210
073                                                                   MAIN1220
074                                                                   MAIN1230
075 .010                                                              MAIN1240
076  5.0
077  1724.
078  1724.
079  1906.
```

```
080  1906.
081  0.0
082  0.0
083  0.0
084  0.0
085  -.000208
086  0.0
087  1.267
088  .0000000437                    MAIN1380
089                                 MAIN1390
090                                 MAIN1400
091   0.0
092  -0.6
093 -.42                            MAIN1430
094                                 MAIN1440
095                                 MAIN1450
096                                 MAIN1460
097                                 MAIN1470
098                                 MAIN1480
099                                 MAIN1490
100                                 MAIN1500
101                                 MAIN1510
102                                 MAIN1520
103                                 MAIN1530
104                                 MAIN1540
105                                 MAIN1550
106                                 MAIN1560
107   1.0                           MAIN1570
108
109  0.0
110  0.0
111  0.0
112  0.0                            MAIN1620
113  1.
114  25.
115  1.0                            MAIN3510
116 .5
117  3.0
118  3.0                            MAIN1680
119                                 MAIN1690
120
121  300.                           MAIN1710
122                                 MAIN1720
123                                 MAIN1730
124                                 MAIN1740
125                                 MAIN1750
126                                 MAIN1760
127
128  3.0                            MAIN1780
129 0.
130  0.06
131  12.0
132  91700.
133  91700.
134  6.26
135  6.26
136  11.0
137  77.
138  5.80
139  0.40
```

```
140 -0.40
141  0.                                                                 MAIN1900
142  0.                                                                 MAIN1910
143                                                                     MAIN1920
144                                                                     MAIN1930
145  0.0
146  0.0
147                                                                     MAIN1960
148                                                                     MAIN1970
149                                                                     MAIN1980
150                                                                     MAIN1990
151                                                                     MAIN2000
152                                                                     MAIN2010
153                                                                     MAIN2020
154                                                                     MAIN2030
155                                                                     MAIN2040
156                                                                     MAIN2050
157                                                                     MAIN2060
158                                                                     MAIN2070
159                                                                     MAIN2080
160                                                                     MAIN2090
161                                                                     MAIN2100
162                                                                     MAIN2110
163                                                                     MAIN2120
164                                                                     MAIN2130
165                                                                     MAIN2140
166                                                                     MAIN2150
167                                                                     MAIN2160
168                                                                     MAIN2170
169  73.
170  73.
171  73.
172 2.                                                                  MAIN2210
173                                                                     MAIN2220
174                                                                     MAIN2230
175 0.25                                                                MAIN2240
176                                                                     MAIN2250
177                                                                     MAIN2260
178                                                                     MAIN2270
179 1.                                                                  MAIN2280
180 3.                                                                  MAIN2290
181  1.                                                                 MAIN2300
182  0.11
183  0.11
184  0.14
185  0.14
186                                                                     MAIN2350
187                                                                     MAIN2360
188                                                                     MAIN2370
189  0.0
190                                                                     MAIN2390
191                                                                     MAIN2400
192  1.0
193                                                                     MAIN2420
194                                                                     MAIN2430
195                                                                     MAIN2440
196  0.
197  0.
198  0.0
199  0.0
```

MAIN2490

200	1.5
201	0.0
202	0.94
203	-.0000893
204	1.20
205	-.000177
206	0.61
207	0.70
208	0.0
209	0.0
210	0.0
211	0.0
212	0.0
213	0.0
214	0.0
215	0.0
216	0.0
217	0.0
218	0.0
219	0.
220	0.
221	0.
222	0.
223	0.0
224	0.0
225	0.0
226	0.0
227	0.0
228	0.0
229	0.0
230	0.0
231	400.
232	400.
233	0.0
234	141.
235	141.
236	210.
237	210.
238	1.50
239	1.50
240	1.00
241	1.00
242	-.0000232
243	-.0000372
244	.00000233
245	-.000109
246	0.0
247	1.216
248	-.0000000135
249	-.003024
250	.003024
251	1.86
252	-.00247
253	.00217
254	1.90
255	0.0
256	-.00166
257	-.00428
258	-3.122
259	0.0

```
260  -.00126
261  -.00377
262  -5.48
263  -0.13
264  -.03
265  .0
266  0.15
267  .015
268  .0
269  0.022
270  .01
271  .0
272  0.0
273  .0
274  .0
275  0.0
276  0.0
277  0.                                                                MAIN3260
278  0.                                                                MAIN3270
279  0.                                                                MAIN3280
280  0.                                                                MAIN3290
281  1.                                                                MAIN3300
282  1.                                                                MAIN3310
283  0.                                                                MAIN3320
284  0.7
285  4.0
286  0.0
287  1.
288  0.                                                                MAIN3370
289  0.                                                                MAIN3380
290  1.0
291  -230.1
292  16.07
293  3473.
294  2.42
295  4590.
001  11.6
004  10.9
005  10.8
006  64.9
007  60.1
011  6800.
012  42551.
013  43465.
092  -0.9
093 -.56
304                                                                    MAIN3580
IOUT(01)  1.                                                           MAIN3590
IOUT(02)  1.                                                           MAIN3600
IOUT(03)  1.                                                           MAIN3610
IOUT(04)  1.                                                           MAIN3620
IOUT(05)  1.                                                           MAIN3630
IOUT(06)  1.                                                           MAIN3640
IOUT(07)  1.                                                           MAIN3650
IOUT(08)  1.                                                           MAIN3660
IOUT(09)  1.                                                           MAIN3670
IOUT(10)  1.                                                           MAIN3680
IOUT(11)  1.                                                           MAIN3690
IOUT(12)  1.                                                           MAIN3700
IOUT(13)  1.                                                           MAIN3710
```

```
                                                MAIN3720
IOUT(14) 1.                                     MAIN3730
IOUT(15) 1.                                     MAIN3740
IOUT(16) 1.                                     MAIN3750
IOUT(17) 1.                                     MAIN3760
IOUT(18) 1.                                     MAIN3770
IOUT(19) 1.                                     MAIN3780
IOUT(20) 1.                                     MAIN3900
IOUT(32) 1.                                     MAIN3890
IOUT(31) 1.                                     MAIN3810
IOUT(23) 1.                                     MAIN3870
IOUT(29) 1.                                     MAIN3830
IOUT(25) 1.                                     MAIN3840
IOUT(26) 1.                                     MAIN3850
IOUT(27) 1.                                     MAIN3860
IOUT(28) 1.                                     MAIN3820
IOUT(24) 1.                                     MAIN3880
IOUT(30) 1.                                     MAIN3800
IOUT(22) 1.                                     MAIN3790
IOUT(21) 1.                                     MAIN3910
IOUT(33) 1.                                     MAIN3920
IOUT(34) 1.                                     MAIN3930
IOUT(35) 1.                                     MAIN3940
IOUT(36) 1.                                     MAIN3950
IOUT(37) 1.
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT 1.0
UOUT 1200.
BTV 3.14
VOUT 1200.
ONER .00417                                     MAIN3990
 DEL1DT -100.                                   MAIN4000
 DEL2DT -100.                                   MAIN4010
 DEL3DT -100.                                   MAIN4020
 DEL1DA 10.                                     MAIN4030
 DEL2DA 10.                                     MAIN4040
 DEL3DA 10.                                     MAIN4050
 PHIRD 1.                                       MAIN4060
 PHIRDA 0.25                                    MAIN4070
DELFW1 0.5                                      MAIN4080
DELFW2 0.5                                      MAIN4090
U1P 2.                                          MAIN4100
U2P 2.                                          MAIN4110
U3P 2.                                          MAIN4120
U4P 2.                                          MAIN4130
S1P 1000.                                       MAIN4140
S2P 1000.                                       MAIN4150
S3P 1000.                                       MAIN4160
S4P 1000.                                       MAIN4170
QUAN1 1.                                        MAIN4180
QUAN2 1.                                        MAIN4190
QUAN3 1.                                        MAIN4200
QUAN4 1.                                        MAIN4210
ARPS1 100.                                      MAIN4220
ARPS2 100.                                      MAIN4230
WSTH1 1.
```

```
WCTH1 1.                                                                                          MAIN4240
WSTH2 1.                                                                                          MAIN4250
WCTH2 1.                                                                                          MAIN4260
066   40.         40.         40.         30.         40.         45.         50.
074   0.          0.          0.          30.         0.          0.          0.
076   5.          10.         10.         5.          5.5         4.          3.
112   0.          0.          0.          0.          0.          0.          0.
114   25.         0.          62.         85.         0.          0.          0.
115   1.          0.          1.          1.          1.          0.          0.
116   .5          100.        .5          .5          .4          100.        100.
117   3.          0.          3.          0.          0.          0.          0.
118   3.          0.          3.          0.          0.          0.          0.
121   300.        200.        200.        0.          0.          0.          1500.
122   0.          0.          0.          0.          0.          0.          0.
123   0.          0.          0.          0.          0.          0.          0.
124   0.          0.          0.          0.          0.          2.          1.
125   0.          0.          0.          0.          0.          0.          1.
126   0.          0.          0.          0.          0.          1.          1.
128   3.          1.          3.          4.          2.          5.          6.
192   1.0         .1          .1          .1          .1          .1          .05
198   0.          0.          0.          12.         0.          0.          0.
199   0.          0.          0.          57.6        0.          0.          0.
201   0.          0.          0.          1000.       0.          0.          0.
238   1.50        1.50        1.50        0.0         0.0         0.0         1.50
239   1.50        1.50        1.50        0.0         0.0         0.0         1.50
240   1.00        1.00        1.00        0.0         0.0         0.0         1.00
241   1.00        1.00        1.00        0.0         0.0         0.0         1.00
277   0.          0.          0.          8.          0.          0.          0.
278   0.          0.          0.          0.          0.          0.          .52
279   0.          0.          0.          0.          0.          0.          1.02
/*      ENDUP
```

```
VEHICLE MODEL - 1971 VOLKWAGEN SUPER BETTLE - CALSPAN -
-1.0      -.5421219 -.03507042-.00111927.000554971.000195158 0.0
2.0       0.0       0.0       0.0       0.0       0.0       0.0        COMM 520
-.16      -.2063332 -.03317212.001250005.000874341.000083333 0.0
-1.3      .7300002  -.01333302.000833121.003333263-.0008333  0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0        COMM 550
0.0       .03416665 -.02541667-.0029166 6.005416665-.00125   0.0
0.0       0.0            TABLE I- FRONT BRAKE TORQUE FUNCTION
1000.     5904.
99999.                                                                 COMM 590
0.0       0.0            TABLE II - REAR BRAKE TORQUE FUNCTION
1000.     5904.
99999.                                                                 COMM 620
0.0        1.00     TABLE III- SIDE FORCE SHAPING FUNCTION
0.05       0.99
0.1        0.97
0.15       0.93
0.2        0.86
0.30       0.72
0.4        0.56
0.6        0.34
0.8        0.25
1.0        0.18
99999.                                                                 COMM 830
 T+D      DUMP     STD      TESTO    LA                                COMM 890
 RESET    TRACK    TABLE    PLOT     DACL                              COMM 900
 ADCL     ZZZZZZZZSTAT      PC       TM                                COMM 910
 CHANGE   READ              CONTROL                                    COMM 920
 I        TEST     X        RE-STR   DACA                              COMM 930
 ADCA     OUTPUT   F        MULTI    TERM                              COMM 940
 MES      IC         ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ              COMM 950
  PSIDT PHIDT PHI ZIMX(1)  ZIMX(3)
                                                                       COMM 980
 PFL AXAVE TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  5.09
002   0.36
003   0.57
004  11.5
005  11.8
006   56.1
007   39.7
008  53.8
009  51.5
010  50.
011  1937.
012  9139.
013  8528.
014   0.0
015   800.
016  0.                                                                COMM1150
017  93000.
018  35.
019  65.7
```

```
020  5.0
021 -1.80
022  3.40
023  0.                                                          COMM1220
024  28300.
025  40.
026  115.
027  2.5
028 -1.85
029  3.35
030  0.0
031  12.6
032  0.                                                          COMM1310
033  1.0                                                         COMM1320
034  5835.
035  -2.89
036  2860.
037  1.79
038  2499.
039  0.0
040   0.957
041  7000.
042   17.0
043  2.5
044  8.0
045  1.6
046  3.9
047   4.4
048 0.0
049   7.35
050   7.35
051   0.3
052   4.13
053  0.0
054  0.0
055  1.66
056  3.75
057 -3.75
058 -.1745
059  .1745
060   1.0                                                        COMM1590
061  0.0
062  0.0
063                                                              COMM1620
064                                                              COMM1630
065                                                              COMM1640
066  40.
067                                                              COMM1660
068                                                              COMM1670
069                                                              COMM1680
070                                                              COMM1690
071  0.0
072                                                              COMM1710
073                                                              COMM1720
074                                                              COMM1730
075  0.010                                                       COMM1740
076  5.0
077  746.
078  746.
079  956.
```

```
VEHICLE MODEL - 1971 VOLKWAGEN SUPER BETTLE - CALSPAN -
-1.0        -.5421219 -.03507042-.00111927.000554971.000195158 0.0
2.0         0.0       0.0       0.0       0.0       0.0       0.0              COMM 520
-.16        -.2063332 -.03317212.001250005.000874341.000083333 0.0
-1.3        .7300002  -.01333302.000833121.003333263-.0008333  0.0
0.0         0.0       0.0       0.0       0.0       0.0       0.0              COMM 550
0.0         .03416665 -.02541667-.0029166.005416665-.00125     0.0
0.0         0.0             TABLE I- FRONT BRAKE TORQUE FUNCTION
1000.       5904.
99999.                                                                         COMM 590
0.0         0.0             TABLE II - REAR BRAKE TORQUE FUNCTION
1000.       5904.
99999.                                                                         COMM 620
0.0          1.00      TABLE III- SIDE FORCE SHAPING FUNCTION
0.05         0.99
0.1          0.97
0.15         0.93
0.2          0.86
0.30         0.72
0.4          0.56
0.6          0.34
0.8          0.25
1.0          0.18
99999.                                                                         COMM 830
 T+D      DUMP     STD      TESTO    LA                                        COMM 890
 RESET    TRACK    TABLE    PLOT     DACL                                      COMM 900
 ADCL     ZZZZZZZZSTAT      PC       TM                                        COMM 910
 CHANGE   READ              CONTROL                                            COMM 920
 I        TEST     X        RE-STR   DACA                                      COMM 930
 ADCA     OUTPUT   F        MULTI    TERM                                      COMM 940
 MES      IC        ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                        COMM 950
  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
                                                                               COMM 980
 PFL AXAVE TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  5.09
002   0.3[illegible]
003   0.57
004  11.5
005  11.8
006   56.1
007   39.7
008  53.8
009  51.5
010  50.
011  1937.
012  9139.
013  8528.
014   0.0
015   800.
016  0.                                                                        COMM1150
017  93000.
018  .35.
019  65.7
```

```
020  5.0
021 -1.80
022  3.40
023  0.                                                          COMM1220
024  28300.
025  40.
026  115.
027  2.5
028 -1.85
029  3.35
030  0.0
031  12.6
032   0.                                                         COMM1310
033  1.0                                                         COMM1320
034  5835.
035  -2.89
036  2860.
037  1.79
038  2499.
039  0.0
040   0.957
041  7000.
042   17.0
043  2.5
044  8.0
045  1.6
046  3.9
047   4.4
048 0.0
049   7.35
050   7.35
051   0.3
052   4.13
053  0.0
054  0.0
055  1.66
056  3.75
057 -3.75
058 -.1745
059  .1745
060   1.0                                                        COMM1590
061  0.0
062  0.0
063                                                              COMM1620
064                                                              COMM1630
065                                                              COMM1640
066  40.
067                                                              COMM1660
068                                                              COMM1670
069                                                              COMM1680
070                                                              COMM1690
071  0.0
072                                                              COMM1710
073                                                              COMM1720
074                                                              COMM1730
075  0.010                                                       COMM1740
076  5.0
077  746.
078  746.
079  956.
```

080	956.	
081	0.0	
082	0.0	
083	0.0	
084	0.0	
085	-.00030	
086	0.0	
087	1.20	
088	0.0	COMM1880
089		COMM1890
090		COMM1900
091	0.0	
092	-1.3	
093	-0.8	COMM1930
094		COMM1940
095		COMM1950
096		COMM1960
097		COMM1970
098		COMM1980
099		COMM1990
100		COMM2000
101		COMM2010
102		COMM2020
103		COMM2030
104		COMM2040
105		COMM2050
106		COMM2060
107	1.0	COMM2070
108		COMM2080
109	0.	
110	0.0	
111	0.0	COMM2110
112	0.	COMM2120
113	1.	
114	25.	
115	1.0	COMM2150
116	.5	
117	3.0	
118	3.0	COMM2180
119		COMM2190
120		
121	300.	COMM2210
122	0.	COMM2220
123		COMM2230
124		COMM2240
125		COMM2250
126	0.	COMM2260
127		
128	3.0	COMM2280
129	0.	
130	0.05	
131	18.	
132	106000.	
133	106000.	
134	5.50	
135	5.50	
136	3.75	
137	57.	
138	5.75	
139	0.0	

```
 0.0
                                                                      COMM2400
                                                                      COMM2410
 0.                                                                   COMM2420
 0.                                                                   COMM2430
 0.0
 0.0
                                                                      COMM2460
                                                                      COMM2470
                                                                      COMM2480
                                                                      COMM2490
                                                                      COMM2500
                                                                      COMM2510
                                                                      COMM2520
                                                                      COMM2530
                                                                      COMM2540
                                                                      COMM2550
                                                                      COMM2560
                                                                      COMM2570
                                                                      COMM2580
                                                                      COMM2590
                                                                      COMM2600
                                                                      COMM2610
                                                                      COMM2620
                                                                      COMM2630
                                                                      COMM2640
                                                                      COMM2650
                                                                      COMM2660
                                                                      COMM2670
 73.
 73.
 73.
2.                                                                    COMM2710
                                                                      COMM2720
                                                                      COMM2730
.2500                                                                 COMM2740
                                                                      COMM2750
                                                                      COMM2760
                                                                      COMM2770
1.                                                                    COMM2780
3.                                                                    COMM2790
 1.                                                                   COMM2800
 0.13
 0.13
 0.20
 0.20
                                                                      COMM2850
                                                                      COMM2860
0.                                                                    COMM2870
0.                                                                    COMM2880
                                                                      COMM2890
                                                                      COMM2900
 1.0
                                                                      COMM2920
                                                                      COMM2930
                                                                      COMM2940
 0.
 0.
```

```
                                                    COMM2990
200  1.5
201
202  0.88
203  0.0
204  0.93
205  0.0
206  0.64
207  0.70
208  0.0
209  0.0
210  0.0
211  0.0
212  0.0
213  0.0
214  0.0
215  0.0
216  0.0
217  0.0
218  0.0
219  0.
220  0.
221  0.
222  0.
223  0.0
224  0.0
225  0.0
226  0.0
227  0.0
228  0.0
229  0.0
230  0.0
231  200.
232  200.
233  0.0
234  65.7
235  65.7
236  115.
237  115.
238  1.44
239  1.44                                           COMM3390
240    1.0                                          COMM3400
241    1.0
     -.0000107
243  -.0000241
244   .00000218
245  -.0000868
246  0.0
247  1.185
248  -.000000134
249  -.00593
250    .00612
251  1.671
252  -.00445
253    .00440
254  .6885
255  0.0
256  -.00245
257  -.00537
258  -.811
259  0.0
```

```
260  -.00184
261  -.00503
262  -1.85
263  0.0
264  .03
265  .0
266  0.29
267  .03
268  0.
269  0.089
270  .01
271  0.
272  0.13
273  .03
274  .0
275  0.0
276  0.0
277  0.                                            COMM3760
278 0.                                             COMM3770
279 0.                                             COMM3780
280  0.                                            COMM3790
281  1.                                            COMM3800
282  1.                                            COMM3810
283  0.                                            COMM3820
284  2.4
285  3.4
286  0.0
287  2.
288  0.0                                           COMM3870
289  0.0                                           COMM3880
290 1.0                                            COMM3890
291  4037.
292  3.87
293  1728.
294  1.41
295  3902.
001  5.50
004  10.8
005  11.2
006  55.9
007  39.9
011  2060.
012  9927.
013  9385.
092  -1.9
093  -1.3
304                                                COMM3950
IOUT(01)  1.                                       COMM3960
IOUT(02)  1.                                       COMM3970
IOUT(03)  1.                                       COMM3980
IOUT(04)  1.                                       COMM3990
IOUT(05)  1.                                       COMM4000
IOUT(06)  1.                                       COMM4010
IOUT(07)  1.                                       COMM4020
IOUT(08)  1.                                       COMM4030
IOUT(09)  1.                                       COMM4040
IOUT(10)  1.                                       COMM4050
IOUT(11)  1.                                       COMM4060
IOUT(12)  1.                                       COMM4070
IOUT(13)  1.                                       COMM4080
```

```
IOUT(14)  1.                              COMM4090
IOUT(15)  1.                              COMM4100
IOUT(16)  1.                              COMM4110
IOUT(17)  1.                              COMM4120
IOUT(18)  1.                              COMM4130
IOUT(19)  1.                              COMM4140
IOUT(20)  1.                              COMM4150
IOUT(32)  1.                              COMM4270
IOUT(31)  1.                              COMM4260
IOUT(23)  1.                              COMM4180
IOUT(29)  1.                              COMM4240
IOUT(25)  1.                              COMM4200
IOUT(26)  1.                              COMM4210
IOUT(27)  1.                              COMM4220
IOUT(28)  1.                              COMM4230
IOUT(24)  1.                              COMM4190
IOUT(30)  1.                              COMM4250
IOUT(22)  1.                              COMM4170
IOUT(21)  1.                              COMM4160
IOUT(33)  1.                              COMM4280
IOUT(34)  1.                              COMM4290
IOUT(35)  1.                              COMM4300
IOUT(36)  1.                              COMM4310
IOUT(37)  1.                              COMM4320
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT 1.0
UOUT 1200.
VOUT 1200.
BTV 3.14
ONER .00417
 DEL1DT -100.                             COMM4360
 DEL2DT -100.                             COMM4370
 DEL3DT -100.                             COMM4380
 DEL1DA 10.                               COMM4390
 DEL2DA 10.                               COMM4400
 DEL3DA 10.                               COMM4410
PHIRD -100.
PSIRDA 10.
DELFW1 0.5                                COMM4440
DELFW2 0.5                                COMM4450
U1P 2.                                    COMM4460
U2P 2.                                    COMM4470
U3P 2.                                    COMM4480
U4P 2.                                    COMM4490
S1P 1000.                                 COMM4500
S2P 1000.                                 COMM4510
S3P 1000.                                 COMM4520
S4P 1000.                                 COMM4530
QUAN1 1.                                  COMM4540
QUAN2 1.                                  COMM4550
QUAN3 1.                                  COMM4560
QUAN4 1.                                  COMM4570
ARPS1 100.                                COMM4580
ARPS2 100.                                COMM4590
WSTH1 1.                                  COMM4600
```

```
WCTH1 1.                                                                      COMM4610
WSTH2 1.                                                                      COMM4620
WCTH2 1.                                                                      COMM4630
066  40.       40.       40.       30.       40.       45.       50.
074  0.        0.        0.        30.       0.        C.        0.
076  5.        10.       10.       5.        5.5       4.        3.
112  0.        0.        0.        0.        0.        0.        0.
114  25.       0.        39.       72.       0.        0.        0.
115  1.        0.        1.        1.        1.        0.        0.
116  .5        100.       .5        .5       .4        100.      100.
117  3.        0.        3.        0.        0.        0.        0.
118  3.        0.        3.        0.        0.        0.        0.
121  300.      200.      200.      0.        0.        0.        1500.
122  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
124  0.        0.        0.        0.        0.        2.        1.
125  0.        0.        0.        0.        0.        0.        1.
126  0.        0.        0.        0.        0.        1.        1.
128  3.        1.        3.        4.        2.        5.        6.
192  1.        .1        .1        .1        .1        .1        .05
198  0.        0.        0.        12.       0.        0.        0.
199  0.        0.        0.        57.6      0.        0.        0.
201  0.        0.        0.        1000.     0.        0.        0.
238  1.44      1.44      1.44      0.0       0.0       0.0       1.44
239  1.44      1.44      1.44      0.0       0.0       0.0       1.44
240  1.00      1.00      1.00      0.0       0.0       0.0       1.00
241  1.00      1.00      1.00      0.0       0.0       0.0       1.00
277  0.        0.        0.        8.        0.        0.        0.
278  0.        0.        0.        0.        0.        0.        .52
279  0.        0.        0.        0.        0.        0.        1.02
./      ENDUP
```

```
VEHICLE MODEL - 1971 PONTIAC TRANS. AM
-0.75      .09643334 .1009879  .00946 1831.001592898-.0015      0.0
-1.0       0.0       0.0       0.0       0.0       0.0       0.0
-0.42      -.03925434-.03157894-.00458558.001719316.000124999 0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0         MAIN4600
0.0        0.0       0.0       0.0       0.0       0.0       0.0         MAIN4610
0.         0.                  TABLE I - FRONT BRAKE TORQUE FUNCTION
1000.      9874.
99999.                                                                  MAIN4650
0.         0.                  TABLE II - REAR BRAKE TORQUE FUNCTION
1000.      9874.
99999.                                                                  MAIN4690
0.0         1.00      TABLE III- SIDE FORCE SHAPING FUNCTION
0.05        0.99
0.1         0.97
0.15        0.93
0.2         0.86
0.30        0.72
0.4         0.56
0.6         0.34
0.8         0.25
1.0         0.18
99999.                                                                  MAIN4870
 T+D      DUMP    STD     TESTO   LA                                    MAIN4930
 RESET    TRACK   TABLE   PLOT    DACL                                  MAIN4940
 ADCL     ZZZZZZZZSTAT    PC      TM                                    MAIN4950
 CHANGE   READ            CCNTROL                                       MAIN4960
 I        TEST    X       RE-STR  DACA                                  MAIN4970
 ADCA     OUTPUT  F       MULTI   TERM                                  MAIN4980
 MES      IC       ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                   MAIN4990
  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)

 PFL AXAVE TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  8.82
002  0.53
003  0.86
004  7.6
005  7.2
006  42.60
007  65.40
008  61.9
009  60.4
010  45.5
011  3523.
012  19125.
013  20092.
014  230.
015  530.
016  0.                                                                 MAIN5190
017  356000.
018  35.
 19  99.
```

```
020  2.0
021 -2.0
022  2.5
023  0.                                                        MAIN5260
024  190000.
025  55.
 26  147.
027  2.0
028 -3.3
029  3.7
030 -0.008
031  12.8
032  0.0
033  1.0
034  -401.85
035  19.08
036  3143.
037  2.82
038  4737.
039  0.0
040  1.07
041  8000.
042  15.5
043  2.0
044  3.5
045  2.0
046  5.0
047  8.0
 48  0.0
049  10.0
050  10.0
051  0.7
052  3.42
 53  0.0
 54  0.0
055 -0.24
056  5.0
057  -5.0
058 -.1527
059  .1527
060  1.0
061  0.0
062  0.0                                                       MAIN5650
063                                                            MAIN5660
064                                                            MAIN5670
065                                                            MAIN5680
066  40.
067                                                            MAIN5700
068                                                            MAIN5710
069                                                            MAIN5720
070                                                            MAIN5730
071  0.0
072                                                            MAIN5750
073                                                            MAIN5760
074                                                            MAIN5770
075 .010                                                       MAIN5780
076  5.0
077  1736.
078  1736.
079  1736.
```

```
080  1736.
081  0.0
082  0.0
083  0.0
084  0.0
085  -.000398
086  0.0
087  1.325
088  .0000000940
089                                         MAIN5920
090                                         MAIN5930
091   0.0                                   MAIN5940
092  -0.6
093 -.67
094                                         MAIN5970
095                                         MAIN5980
096                                         MAIN5990
097                                         MAIN6000
098                                         MAIN6010
099                                         MAIN6020
100                                         MAIN6030
101                                         MAIN6040
102                                         MAIN6050
103                                         MAIN6060
104                                         MAIN6070
105                                         MAIN6080
106                                         MAIN6090
107   1.0                                   MAIN6100
108                                         MAIN6110
109  0.0
110  0.0
111  0.0
112  0.0
113  1.                                     MAIN6160
114  25.
115  1.0
116  0.5
117  3.0
118  3.0
119                                         MAIN6220
120                                         MAIN6230
121   300.
122                                         MAIN6250
123                                         MAIN6260
124                                         MAIN6270
125                                         MAIN6280
126                                         MAIN6290
127                                         MAIN6300
128   3.0
129 0.                                      MAIN6320
130   0.06
131   14.0
132   87000.
133   87000.
134   6.26
135   6.26
136   11.0
137   69.
138   5.87
139   0.67
```

140	-0.67
141	0.
142	0.
143	
144	
145	0.0
146	0.0
147	
148	
149	
150	
151	
152	
153	
154	
155	
156	
157	
158	
159	
160	
161	
162	
163	
164	
165	
166	
167	
168	
169	73.
170	73.
171	73.
172	2.
173	
174	
175	0.25
176	
177	
178	
179	1.
180	3.
181	1.
182	0.14
183	0.14
184	0.14
185	0.14
186	
187	
188	
189	0.0
190	
191	
192	1.0
193	
194	
195	
196	0.
197	0.
198	0.
199	0.

```
200  1.5                MAIN7030
201  0.
202  1.09
203  0.0
204  1.09
205  0.0
206  0.79
207  0.79
208  0.0
209  0.0
210  0.0
211  0.0
212  0.0
213  0.0
214  0.0
215  0.0
216  0.0
217  0.0
218  0.0
219  0.
220  0.
221  0.
222  0.
223  0.0
224  0.0
225  0.0
226  0.0
227  0.0
228  0.0
229  0.0
230  0.0
231  400.
232  400.
233  0.0
234  99.
235  99.
236  147.
237  147.
238  1.67
239  1.67
240   1.0               MAIN7430
241   1.0               MAIN7440
242  -.0000281
243  -.0000346
244  .00000262
245  -.000398
246  0.0
247  1.325
248  .0000000940
249  -.002796
250  .00282
251  2.298
252  -.002796
253  .00282
254  2.298
255  0.0
256  -.0008976
257  -.00419
258  -10.04
259  0.0
```

```
260  -.0008976
261   -.00419
262  -10.04
263  -0.09
264  -.03
265  .0
266  0.15
267  .015
268  .0
269  0.064
270  .01
271  .0
272  0.0
273  .0
274  .0
275  0.0
276  0.0
277  0.                                                       MAIN7800
278  0.                                                       MAIN7810
279  0.                                                       MAIN7820
280  0.                                                       MAIN7830
281  1.                                                       MAIN7840
282  1.                                                       MAIN7850
283  0.                                                       MAIN7860
284  2.0
285  5.7
286  0.0
287  1.
288  0.                                                       MAIN7910
289  0.                                                       MAIN7920
290  1.0
291  -401.85
292  19.08
293  3143.
294  2.82
295  4737.
001  9.27
004  6.7
005  6.7
006  42.25
007  65.75
011  3724.
012  20199.
013  21291.
092  -1.3
093 -.79
304                                                           MAIN8120
IOUT(01)  1.                                                  MAIN8130
IOUT(02)  1.                                                  MAIN8140
IOUT(03)  1.                                                  MAIN8150
IOUT(04)  1.                                                  MAIN8160
IOUT(05)  1.                                                  MAIN8170
IOUT(06)  1.                                                  MAIN8180
IOUT(07)  1.                                                  MAIN8190
IOUT(08)  1.                                                  MAIN8200
IOUT(09)  1.                                                  MAIN8210
IOUT(10)  1.                                                  MAIN8220
IOUT(11)  1.                                                  MAIN8230
IOUT(12)  1.                                                  MAIN8240
IOUT(13)  1.                                                  MAIN8250
```

```
IOUT(14)  1.                                MAIN8260
IOUT(15)  1.                                MAIN8270
IOUT(16)  1.                                MAIN8280
IOUT(17)  1.                                MAIN8290
IOUT(18)  1.                                MAIN8300
IOUT(19)  1.                                MAIN8310
IOUT(20)  1.                                MAIN8320
IOUT(32)  1.                                MAIN8440
IOUT(31)  1.                                MAIN8430
IOUT(23)  1.                                MAIN8350
IOUT(29)  1.                                MAIN8410
IOUT(25)  1.                                MAIN8370
IOUT(26)  1.                                MAIN8380
IOUT(27)  1.                                MAIN8390
IOUT(28)  1.                                MAIN8400
IOUT(24)  1.                                MAIN8360
IOUT(30)  1.                                MAIN8420
IOUT(22)  1.                                MAIN8340
IOUT(21)  1.                                MAIN8330
IOUT(33)  1.                                MAIN8450
IOUT(34)  1.                                MAIN8460
IOUT(35)  1.                                MAIN8470
IOUT(36)  1.                                MAIN8480
IOUT(37)  1.                                MAIN8490
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT 1.0
UOUT 1200.
BTV 3.14
 PHIDT .8
 PHI .2
 DEL1DT -100.                               MAIN8530
 DEL2DT -100.                               MAIN8540
 DEL3DT -100.                               MAIN8550
 DEL1DA 10.                                 MAIN8560
 DEL2DA 10.                                 MAIN8570
 DEL3DA 10.                                 MAIN8580
 PHIRD 1.                                   MAIN8590
PHIRDA 0.25                                 MAIN8600
DELFW1 0.5                                  MAIN8610
DELFW2 0.5                                  MAIN8620
U1P 2.                                      MAIN8630
U2P 2.                                      MAIN8640
U3P 2.                                      MAIN8650
U4P 2.                                      MAIN8660
S1P 1000.                                   MAIN8670
S2P 1000.                                   MAIN8680
S3P 1000.                                   MAIN8690
S4P 1000.                                   MAIN8700
QUAN1 1.                                    MAIN8710
QUAN2 1.                                    MAIN8720
QUAN3 1.                                    MAIN8730
QUAN4 1.                                    MAIN8740
ARPS1 100.                                  MAIN8750
ARPS2 100.                                  MAIN8760
WSTH1 1.                                    MAIN8770
```

```
2     WCTH1 1.                                                                        MAIN8780
2     WSTH2 1.                                                                        MAIN8790
2     WCTH2 1.                                                                        MAIN8800
2     066  40.       40.       40.       30.       40.       45.       50.
2     074  0.        0.        0.        30.       0.        0.        0.
2     076  5.        10.       10.       5.        5.5       4.        3.
2     112  0.        0.        0.        0.        0.        0.        0.
2     114  25.       0.        52.       90.       0.        0.        0.
2     115  1.        0.        1.        1.        1.        0.        0.
2     116  .5        100.      .5        .5        .4        100.      100.
2     117  3.        0.        3.        0.        0.        0.        0.
2     118  3.0       0.        3.        0.        0.        0.        0.
2     121  300.      200.      200.      0.        0.        0.        1500.
2     122  0.        0.        0.        0.        0.        0.        0.
2     123  0.        0.        0.        0.        0.        0.        0.
      124  0.        0.        0.        0.        0.        2.        1.
      125  0.        0.        0.        0.        0.        0.        1.
      126  0.        0.        0.        0.        0.        1.        1.
      128  3.        1.        3.        4.        2.        5.        6.
      192  1.0       .1        .1        .1        .1        .1        .05
      198  0.        0.        0.        12.       0.        0.        0.
      199  0.        0.        0.        57.6      0.        0.        0.
      201  0.        0.        0.        1000.     0.        0.        0.
      238  1.67      1.67      1.67      0.0       0.0       0.0        1.67
      239  1.67      1.67      1.67      0.0       0.0       0.0       1.67
      240  1.00      1.00      1.00      0.00      0.00      0.00      1.00
      241  1.00      1.00      1.00      0.00      0.00      0.00      1.00
      277  0.        0.        0.        8.        0.        0.        0.
      278  0.        0.        0.        0.        0.        0.        .52
      279  0.        0.        0.        0.        0.        0.        1.02
      ./      ENDUP
```

2. PRESENTED HERE ARE THE WHEEL SPRING AND SHOCK ABSORBER CHARACTERISTICS

WHEEL SPRING CHARACTERISTICS

The entries in this table are the values of the slopes versus suspension displacement for the no-load vehicle configuration. The units of the entries are lbs/in and inches.

Vehicle	Spring Force Effective at the Front Wheel	Spring Force Effective at the Spring for the Rear Suspension
Dodge Coronet		
	588 for $\delta \geq 2.1$	864 for $\zeta \geq 3.6$
	105 for $-2.4 < \delta < 2.1$	120 for $-4.4 < \zeta < 3.6$
	189 for $\delta \leq -2.4$	324 for $\zeta \leq -4.4$
Pontiac Trans Am		
	347 for $\delta \geq 2.5$	735 for $\zeta \geq 3.7$
	99 for $-2.0 < \delta < 2.5$	147 for $-3.3 < \zeta < 3.7$
	198 for $\delta \leq -2.0$	294 for $\zeta \leq -3.3$
Chevrolet Brookwood		
	592 for $\delta \geq 2.3$	1071 for $\zeta \geq 2.3$
	141 for $-3.5 < \delta < 2.3$	210 for $-3.6 < \zeta < 2.3$
	282 for $\delta \leq -3.5$	399 for $\zeta \leq -3.6$
Volkswagen Super Beetle		
	526 for $\delta \geq 3.40$	449 for $\zeta \geq 3.35$
	65.7 for $-1.80\ \delta < 3.40$	115 for $-1.85 < \zeta < 3.35$
	164 for $\delta \leq -1.80$	184 for $\zeta \leq -1.85$

SHOCK ABSORBER CHARACTERISTICS

The entries in this table are the values of the slopes versus wheel ride motion. The units of the entries are lbs/(in/sec) and in/sec.

Vehicle	For Shock Absorber Damping Effective at the Front Wheel	For Shock Absorber Damping Effective at the Rear Wheel
Dodge Coronet		
	4.33 for $V \geq 0$	1.50 for $V \geq 7.2$
	9.36 for $V < 0$	8.32 for $0 \leq V < 7.2$
		6.63 for $V < 0$
Pontiac Trans Am		
	1.79 for $V \geq 21.9$	0.79 for $V \geq 15.8$
	7.78 for $10.2 \leq V < 21.9$	1.99 for $0 \leq V < 15.8$
	2.74 for $0 \leq V < 10.2$	4.58 for $-11.3 \leq V < 0$
	21.0 for $-7.46 \leq V < 0$	1.01 for $V < -11.3$
	3.10 for $V < -7.46$	
Chevrolet Brookwood		
	1.94 for $V \geq 0$	1.62 for $V \geq 0$
	12.1 for $-10.2 \leq V < 0$	9.99 for $-10.1 \leq V < 0$
	1.17 for $V < -10.2$	1.61 for $V < -10.1$
Volkswagen Super Beetle		
	1.81 for $V \geq 12.0$	1.89 for $V \geq 0$
	4.28 for $0 \leq V < 12.0$	8.06 for $-19.1 \leq V < 0$
	5.73 for $-12.6 \leq V < 0$	2.87 for $V < -19.1$
	11.4 for $-16.5 \leq V < -12.6$	
	4.44 for $V < -16.5$	

3. PRESENTED HERE ARE THE CAMBER AND TOE DATA

CAMBER AND TOE DATA

To obtain these data, the wheel was moved from the full rebound position to compression bump stop. In order to use these data in calculations, one must know the values of camber and toe at a reference value of suspension displacement which depends upon vehicle loading. The data presented here were measured with reference to a no-load vehicle configuration.

Vehicle	Displacement	Camber	Toe
Dodge Coronet (left front)	0	0	0
(static displacement = 3.0)	1	0.41	-0.37
	2	0.98	-0.59
	3	1.26	-0.85
	4	1.22	-1.05
	5	0.95	-1.21
	6	0.43	-1.36
Pontiac Trans Am (left front)	0	0	0
(static displacement = 4.0)	1	0.26	-0.03
	2	0.83	-0.18
	3	1.27	-0.31
	4	1.48	-0.39
	5	1.48	-0.40
	6	1.27	-0.40
Chevrolet Brookwood (left front)	0	0	0
(static displacement = 3.0)	1	0.85	-0.24
	2	1.68	-0.53
	3	2.18	-0.73
	4	2.43	-0.89
	5	2.47	-1.01
	6	2.29	-1.10
	7	1.96	-1.17

CAMBER AND TOE DATA (Cont'd)

Vehicle	Displacement	Camber	Toe
VW Super Beetle (right rear)	0	0	0
(static displacement = 3.0)	1	-0.72	0.06
	2	-1.44	0.08
	3	-2.16	0.07
	4	-2.90	0.02
	5	-3.60	0.05
VW Super Beetle (left front)	0	0	0
(static displacement = 4.0)	1	-0.57	-0.17
	2	-1.25	-0.45
	3	-1.87	-0.73
	4	-2.46	-0.96
	5	-2.96	-1.14
	6	-3.42	-1.25
	7	-3.79	-1.30
	8	-4.08	-1.32

4. PRESENTED HERE ARE THE PARAMETER TABLE OUTPUT

```
PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 DODGE CORONET
  1   MS=  8.4300       ,  2   MUF= 0.51000      ,  3   MUP= 0.82000      ,  4   ZF=  11.300       ,  5   ZR=  11.300       ,
  6   A=  49.300        ,  7   B=  68.700        ,  8   TF=  59.800       ,  9   TR=  61.800       , 10   TS=  47.000       ,
 11   IX=  3758.0       , 12   IY=  23047.       , 13   IZ=  23327.       , 14   IXZ=  530.00      , 15   IR=  550.00       ,
 16   CF= 0.0           , 17   RF=  40400.       , 18   CFPR=  40.000     , 19   KF=  105.00       , 20   LAMF=  2.0000     ,
 21   UMFC= -2.4000     , 22   OMFT=  2.1000     , 23   CR= 0.0           , 24   RR= -5100.0       , 25   CRPR=  38.000     ,
 26   KR=  120.00       , 27   LAMR=  2.0000     , 28   OMPC= -4.4000     , 29   OMRT=  3.6000     , 30   KRS= 0.20000E-01,
 31   RW=  13.200       , 32      = 0.0          , 33   FOT= 0.75000      , 34   A0=  2701.0       , 35   A1=  10.140       ,
 36   A2=  2533.0       , 37   A3=  1.3000       , 38   A4=  4591.0       , 39      = 0.0          , 40      =  1.2700      ,
 41   K5C=  8000.0      , 42   NG=  14.200       , 43   LAFC=  1.8000     , 44   LAFT=  5.6000     , 45   LARC=  2.7000     ,
 46   LART=  7.2000     , 47   IFW=  6.4000      , 48      = 0.0          , 49   IWF=  9.4000      , 50   IWR=  9.4000      ,
 51   ID= 0.70000       , 52   AR=  2.7100       , 53      = 0.0          , 54      = 0.0          , 55   PT=-0.66000       ,
 56   YSA1=  4.5900     , 57   YSA2= -4.5900     , 58   PHS1=-0.13090     , 59   PHS2= 0.13090     , 60   CTSW=  1.0000     ,
 61      = 0.0          , 62      = 0.0          , 63   P-IN= 0.0         , 64   Q-IN= 0.0         , 65   R-IN= 0.0         ,
 66   U-IN=  40.000     , 67   V-IN= 0.0         , 68   W-IN= 0.0         , 69   X-IN= 0.0         , 70   Y-IN= 0.0         ,
 71   Z-IN= -23.838     , 72   THIN=-0.69610E-01, 73   PHIN= 0.0         , 74   PSIN= 0.0         , 75   DT= 0.10000E-01,
 76   TN=  5.0000       , 77   KT1=  1450.0      , 78   KT2=  1450.0      , 79   KT3=  1450.0      , 80   KT4=  1450.0      ,
 81   RPS1=  56.419     , 82   RPS2=  56.419     , 83   RPS3=  55.778     , 84   RPS4=  55.778     , 85   B1=-0.33000E-03,
 86   B2= 0.0           , 87   B3=  1.2280       , 88   B4= 0.75900E-07, 89   O1DT= 0.0         , 90   O2DT= 0.0         ,
 91   O3DT= 0.0         , 92   DEL1=-0.80000     , 93   DEL2=-0.68000     , 94   DEL3= 0.0         , 95   PHDT= 0.0         ,
 96   PHIR= 0.0         , 97   DFW1= 0.0         , 98   DFW2= 0.0         , 99   U1PR= 0.0         ,100   U2PR= 0.0         ,
101   U3PR= 0.0         ,102   U4PR= 0.0         ,103   S1PR= 0.0         ,104   S2PR= 0.0         ,105   S3PR= 0.0         ,
106   S4PR= 0.0         ,107   PPRT=  1.0000     ,108      = 0.0          ,109      = 0.0          ,110   TQMX= 0.0         ,
111   KTQ= 0.0          ,112   VC= 0.0           ,113   MTSW=  1.0000     ,114   OSWM=  25.000     ,115   TST=  1.0000      ,
116   DSLP= 0.50000     ,117   CGAM=  3.0000     ,118   C5=  3.0000       ,119      = 0.0          ,120      = 0.0          ,
121   PFLE=  300.00     ,122   T1= 0.0           ,123   D5W= 0.0          ,124   T5W= 0.0          ,125   I5W5= 0.0         ,
126   SW15= 0.0         ,127   PQSW= 0.0         ,128   VTPS=  3.0000     ,129   VHTP= 0.0         ,130   AMCR= 0.60000E-01,
131   ESP=  16.000      ,132   K5L1=  55900.     ,133   K5L2=  55900.     ,134   AA1=  6.6200      ,135   AA2=  6.6200      ,
136   CCR=  11.000      ,137   CFCR=  54.000     ,138   AP=  5.2000       ,139   EP1= 0.45000      ,140   EP2=-0.45000      ,
141   ERR1= 0.0         ,142   ERR2= 0.0         ,143   AML1= 0.0         ,144   AML2= 0.0         ,145   RRIM= 0.0         ,
146      = 0.0          ,147      = 0.0          ,148      = 0.0          ,149      = 0.0          ,150      = 0.0          ,
151      = 0.0          ,152      = 0.0          ,153      = 0.0          ,154      = 0.0          ,155      = 0.0          ,
156      = 0.0          ,157      = 0.0          ,158      = 0.0          ,159      = 0.0          ,160      = 0.0          ,
161      = 0.0          ,162      = 0.0          ,163      = 0.0          ,164      = 0.0          ,165      = 0.0          ,
166      = 0.0          ,167      = 0.0          ,168      = 0.0          ,169   SNT=  73.000      ,170   SNS0=  73.000     ,
171   SNS1=  73.000     ,172   SNSW=  2.0000     ,173   OIST= 0.0         ,174   PL = 0.0          ,175   TSCP= 0.25000     ,
176      = 0.0          ,177      = 0.0          ,178      = 0.0          ,179      =  1.0000      ,180   PASS=  3.0000     ,
181      =  1.0000      ,182   SI1= 0.17000      ,183   SI2= 0.17000      ,184   SI3= 0.17000      ,185   SI4= 0.17000      ,
186      = 0.0          ,187      = 0.0          ,188      = 0.0          ,189      = 0.0          ,190      = 0.0          ,
191      = 0.0          ,192   MTQB=  1.0000     ,193   ORSW= 0.0         ,194   LDF= 0.0          ,195   LORF= 0.0         ,
196   EK1= 0.0          ,197   EK2= 0.0          ,198   BMPL= 0.0         ,199   BMPS= 0.0         ,200   BMPH=  1.5000     ,
201   .XB= 0.0          ,202   APF1= 0.94000     ,203   APF2=-0.80000E-04,204   APR1= 0.94000     ,205   APR2=-0.80000E-04,
206   MUSF= 0.65000     ,207   MUSR= 0.65000     ,208      = 0.0          ,209      = 0.0          ,210      = 0.0          ,
211      = 0.0          ,212      = 0.0          ,213      = 0.0          ,214      = 0.0          ,215      = 0.0          ,
216      = 0.0          ,217      = 0.0          ,218      = 0.0          ,219   FEE1= 0.0         ,220   FEE2= 0.0         ,
221   THE1= 0.0         ,222   THE2= 0.0         ,223      = 0.0          ,224      = 0.0          ,225      = 0.0          ,
226      = 0.0          ,227      = 0.0          ,228      = 0.0          ,229      = 0.0          ,230      = 0.0          ,
231   HI=  400.00       ,232   H2=  400.00       ,233      = 0.0          ,234   AKF1=  105.00     ,235   AKF2=  105.00     ,
236   AKF3=  120.00     ,237   AKF4=  120.00     ,238   BR1=  1.0000      ,239   BR2=  1.0000      ,240   BR3= 0.67000      ,
241   BR4= 0.67000      ,242   KCF=-0.39300E-04,243   KCR=-0.33200E-04,244   K5R= 0.17500E-05,245   RB1=-0.33000E-03,
246   RB2= 0.0          ,247   RB3=  1.2280      ,248   RB4= 0.75900E-07,249   AFK1=-0.31800E-02,250   AFK2= 0.34900E-02,
251   AFK3=  1.4040     ,252   ARK1=-0.31800E-02,253   ARK2= 0.34900E-02,254   ARK3=  1.4040     ,255   OFC0= 0.0         ,
256   OFC1=-0.15000E-02,257   OFC2=-0.52440E-02,258   OFC3= -5.5920     ,259   ORC0= 0.0         ,260   ORC1=-0.15000E-02,
261   ORC2=-0.52440E-02,262   ORC3= -5.5920     ,263   CP0F=-0.13000     ,264   CP1F=-0.30000E-01,265   CP2F= 0.0         ,
266   CP0R= 0.15000     ,267   CP1R= 0.15000E-01,268   CP2R= 0.0         ,269   CR0F= 0.89000E-01,270   CR1F= 0.10000E-01,
271   CR2F= 0.0         ,272   CR0R= 0.0         ,273   CR1R= 0.0         ,274   CR2R= 0.0         ,275      = 0.0          ,
276      = 0.0          ,277   BMPN= 0.0         ,278   TQA0= 0.0         ,279   TQB1= 0.0         ,280      = 0.0          ,
281      =  1.0000      ,282      =  1.0000      ,283      = 0.0          ,284   HFC=  2.7000      ,285   HRC=  3.9000      ,
286      = 0.0          ,287   AXLE=  1.0000     ,288      = 0.0          ,289      = 0.0          ,290   ROT = 0.75000     ,
291   RA0 =  2701.0     ,292   RA1 =  10.140     ,293   RA2 =  2533.0     ,294   RA3 =  1.3000     ,295   RA4 =  4591.0     ,
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PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 CHEVROLET BROOKWOOD STATION WAGON
  1     MS=  11.600     ,   2     MUF= 0.63000     ,   3    MUR=  1.0300     ,   4      ZF=  10.900     ,   5      ZR=  10.800     ,
  6      A=  64.900     ,   7       B=  60.100     ,   8     TF=  63.500     ,   9      TR=  63.500     ,  10      TS=  45.300     ,
 11     IX=  6800.0     ,  12      IY=  42551.     ,  13     IZ=  43465.     ,  14     IXZ=  1790.0     ,  15      IR=  750.00     ,
 16     CF= 0.0         ,  17      RF= 0.40800E 06,  18   CFPR=  43.000     ,  19      KF=  141.00     ,  20    LAMF=  2.0000     ,
 21   OMFC= -3.5000     ,  22    OMFT=  2.3000     ,  23     CR= 0.0         ,  24      RR= -62000.     ,  25    CRPR=  73.000     ,
 26     KR=  210.00     ,  27    LAMR=  2.0000     ,  28   OMRC= -3.6000     ,  29    OMRT=  2.3000     ,  30     KRS= 0.33000E-01,
 31     RW=  14.400     ,  32        = 0.0         ,  33    FOT=  1.0000     ,  34      A0=  585.91     ,  35      A1=  14.470     ,
 36     A2=  2886.0     ,  37      A3=  2.2900     ,  38     A4=  4057.0     ,  39        = 0.0         ,  40        =  1.0800     ,
 41    KSC=  8000.0     ,  42      NG=  16.200     ,  43   LAFC=  2.0000     ,  44    LAFT=  4.2000     ,  45    LARC=  1.9000     ,
 46   LART=  5.1000     ,  47     IFW=  10.000     ,  48       = 0.0         ,  49     IWF=  14.800     ,  50     IWR=  14.800     ,
 51     IJ= 0.70000     ,  52      AR=  3.0800     ,  53       = 0.0         ,  54        = 0.0         ,  55      PT= 0.16000     ,
 56   YSA1=  5.2500     ,  57    YSA2= -5.2500     ,  58   PHS1=-0.17450     ,  59    PHS2= 0.17450     ,  60    CTSW=  1.0000     ,
 61       = 0.0         ,  62        = 0.0         ,  63   P-IN= 0.0         ,  64    Q-IN= 0.0         ,  65    R-IN= 0.0         ,
 66   U-IN=  40.000     ,  67    V-IN= 0.0         ,  68   W-IN= 0.0         ,  69    X-IN= 0.0         ,  70    Y-IN= 0.0         ,
 71   Z-IN= -24.542     ,  72    THIN= 0.54671E-01,  73   PHIN= 0.0         ,  74    PSIN= 0.0         ,  75      DT= 0.10000E-01,
 76     TN=  5.0000     ,  77     KT1=  1724.0     ,  78    KT2=  1724.0     ,  79     KT3=  1906.0     ,  80     KT4=  1906.0     ,
 81   RPS1=  51.370     ,  82    RPS2=  51.370     ,  83   RPS3=  51.443     ,  84    RPS4=  51.443     ,  85      B1=-0.20800E-03,
 86     B2= 0.0         ,  87      B3=  1.2670     ,  88     B4= 0.43700E-08,  89    D1DT= 0.0         ,  90    D2DT= 0.0         ,
 91   D3DT= 0.0         ,  92    DEL1=-0.90000     ,  93   DEL2=-0.56000     ,  94    DEL3= 0.0         ,  95    PHDT= 0.0         ,
 96   PHIR= 0.0         ,  97    DFW1= 0.0         ,  98   DFW2= 0.0         ,  99    U1PR= 0.0         , 100    U2PR= 0.0         ,
101   U3PR= 0.0         , 102    U4PR= 0.0         , 103   S1PR= 0.0         , 104    S2PR= 0.0         , 105    S3PR= 0.0         ,
106   S4PR= 0.0         , 107    PPRT=  1.0000     , 108       = 0.0         , 109        = 0.0         , 110    TQMX= 0.0         ,
111    KTJ= 0.0         , 112      VC= 0.0         , 113    MTSW=  1.0000     , 114    DSWM=  25.000     , 115     TST=  1.0000     ,
116   DSLP= 0.50000     , 117    CGAM=  3.0000     , 118     CS=  3.0000     , 119        = 0.0         , 120        = 0.0         ,
121    PFL=  300.00     , 122      T1= 0.0         , 123    DSW= 0.0         , 124     TSW= 0.0         , 125    ISW5= 0.0         ,
126   SW15= 0.0         , 127    PQSW= 0.0         , 128   VTPS=  3.0000     , 129    VHTP= 0.0         , 130    AMCR= 0.60000E-01,
131    ESP=  12.000     , 132    KSL1=  91700.     , 133   KSL2=  91700.     , 134     AA1=  6.2600     , 135     AA2=  6.2600     ,
136    CCR=  11.000     , 137    CFCR=  77.000     , 138     AP=  5.8000     , 139     EP1= 0.40000     , 140     EP2=-0.40000     ,
141   ERR1= 0.0         , 142    ERR2= 0.0         , 143   AML1= 0.0         , 144    AML2= 0.0         , 145    RR1M= 0.0         ,
146       = 0.0         , 147        = 0.0         , 148       = 0.0         , 149        = 0.0         , 150        = 0.0         ,
151       = 0.0         , 152        = 0.0         , 153       = 0.0         , 154        = 0.0         , 155        = 0.0         ,
156       = 0.0         , 157        = 0.0         , 158       = 0.0         , 159        = 0.0         , 160        = 0.0         ,
161       = 0.0         , 162        = 0.0         , 163       = 0.0         , 164        = 0.0         , 165        = 0.0         ,
166       = 0.0         , 167        = 0.0         , 168       = 0.0         , 169     SNT=  73.000     , 170    SNS0=  73.000     ,
171   SNS1=  73.000     , 172    SNSW=  2.0000     , 173   DIST= 0.0         , 174     PL = 0.0         , 175    TSCP= 0.25000     ,
176       = 0.0         , 177        = 0.0         , 178       = 0.0         , 179        =  1.0000     , 180    PASS=  3.0000     ,
181       =  1.0000     , 182     S11= 0.11000     , 183    S12= 0.11000     , 184     S13= 0.14000     , 185     S14= 0.14000     ,
186       = 0.0         , 187        = 0.0         , 188       = 0.0         , 189        = 0.0         , 190        = 0.0         ,
191       = 0.0         , 192    MTQB=  1.0000     , 193   DRSW= 0.0         , 194     LDF= 0.0         , 195    LDRF= 0.0         ,
196    EK1= 0.0         , 197     EK2= 0.0         , 198   BMPL= 0.0         , 199    BMPS= 0.0         , 200    BMPH=  1.5000     ,
201     XB= 0.0         , 202    APF1= 0.94000     , 203   APF2=-0.89300E-04, 204    APR1=  1.2000     , 205    APR2=-0.17700E-03,
206   MUSF= 0.61000     , 207    MUSR= 0.70000     , 208       = 0.0         , 209        = 0.0         , 210        = 0.0         ,
211       = 0.0         , 212        = 0.0         , 213       = 0.0         , 214        = 0.0         , 215        = 0.0         ,
216       = 0.0         , 217        = 0.0         , 218       = 0.0         , 219    FEE1= 0.0         , 220    FEE2= 0.0         ,
221   THE1= 0.0         , 222    THE2= 0.0         , 223       = 0.0         , 224        = 0.0         , 225        = 0.0         ,
226       = 0.0         , 227        = 0.0         , 228       = 0.0         , 229        = 0.0         , 230        = 0.0         ,
231     H1=  400.00     , 232      H2=  400.00     , 233       = 0.0         , 234    AKF1=  141.00     , 235    AKF2=  141.00     ,
236   AKF3=  210.00     , 237    AKF4=  210.00     , 238    BR1=  1.5000     , 239     BR2=  1.5000     , 240     BR3=  1.0000     ,
241    BR4=  1.0000     , 242     KCF=-0.23200E-04, 243    KCR=-0.37200E-04, 244     KSR= 0.23300E-05, 245     RB1=-0.10900E-03,
246    RB2= 0.0         , 247     RB3=  1.2160     , 248    RB4=-0.13500E-07, 249    AFK1=-0.30240E-02, 250    AFK2= 0.30240E-02,
251   AFK3=  1.8600     , 252    ARK1=-0.24700E-02, 253   ARK2= 0.21700E-02, 254    ARK3=  1.9000     , 255    OFC0= 0.0         ,
256   OFC1=-0.16600E-02, 257    OFC2=-0.42800E-02, 258   DFC3= -3.1220     , 259    ORC0= 0.0         , 260    ORC1=-0.12600E-02,
261   ORC2=-0.37700E-02, 262    ORC3= -5.4800     , 263   CP0F=-0.13000     , 264    CP1F=-0.30000E-01, 265    CP2F= 0.0         ,
266   CP0R= 0.15000     , 267    CP1R= 0.15000E-01, 268   CP2R= 0.0         , 269    CR0F= 0.22000E-01, 270    CR1F= 0.10000E-01,
271   CR2F= 0.0         , 272    CR0R= 0.0         , 273   CR1R= 0.0         , 274    CR2R= 0.0         , 275        = 0.0         ,
276       = 0.0         , 277    RMPN= 0.0         , 278   TQR0= 0.0         , 279    TUB1= 0.0         , 280        = 0.0         ,
281       =  1.0000     , 282        =  1.0000     , 283       = 0.0         , 284     HFC= 0.70000     , 285     HRC=  4.0000     ,
286       = 0.0         , 287    AXLE=  1.0000     , 288       = 0.0         , 289        = 0.0         , 290     ROT =  1.0000     ,
291    RA0 = -230.10    , 292     RA1 =  16.070    , 293    RA2 =  3473.0    , 294     RA3 =  2.4200    , 295     RA4 =  4590.0    ,
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PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 VOLKWAGEN SUPER BETTLE - CALSPAN -
  1     MS=  5.5000   ,   2       F= 0.36000   ,   3   MUR= 0.57000   ,   4     ZF=  10.800    ,   5     ZR=  11.200    ,
  6      A=  55.900   ,   7       B=  39.900   ,   8    TF=  53.800   ,   9     TR=  51.500    ,  10     TS=  50.000    ,
 11     IX=  2060.0   ,  12      IY=  9927.0   ,  13    IZ=  9385.0   ,  14    IXZ= 0.0        ,  15     IR=  800.00    ,
 16     CF= 0.0       ,  17      RF=  93000.   ,  18  CFPR=  35.000   ,  19     KF=  65.700    ,  20   LAMF=  5.0000    ,
 21   OMFC= -1.8000   ,  22    OMFT=  3.4000   ,  23    CR= 0.0       ,  24     RR=  28300.    ,  25   CRPR=  40.000    ,
 26     KR=  115.00   ,  27    LAMR=  2.5000   ,  28  OMRC= -1.8500   ,  29   OMRT=  3.3500    ,  30    KRS= 0.0        ,
 31     RW=  12.600   ,  32        = 0.0       ,  33   FDT=  1.0000   ,  34     A0=  5835.0    ,  35     A1= -2.8900    ,
 36     A2=  2860.0   ,  37      A3=  1.7900   ,  38    A4=  2499.0   ,  39        = 0.0       ,  40        = 0.95700   ,
 41    KSC=  7000.0   ,  42      NG=  17.000   ,  43  LAFC=  2.5000   ,  44   LAFI=  8.0000    ,  45   LARC=  1.6000    ,
 46   LART=  3.9000   ,  47     IFW=  4.4000   ,  48       = 0.0      ,  49    IWF=  7.3500    ,  50    IWR=  7.3500    ,
 51     ID= 0.30000   ,  52      AR=  4.1300   ,  53       = 0.0      ,  54        = 0.0       ,  55     PT=  1.6600    ,
 56   YSA1=  3.7500   ,  57    YSA2= -3.7500   ,  58 PHS1=-0.17450    ,  59   PHS2= 0.17450    ,  60   CTSW=  1.0000    ,
 61        = 0.0      ,  62        = 0.0       ,  63  P-IN= 0.0       ,  64   Q-IN= 0.0        ,  65   R-IN= 0.0        ,
 66   U-IN=  40.000   ,  67    V-IN= 0.0       ,  68  W-IN= 0.0       ,  69   X-IN= 0.0        ,  70   Y-IN= 0.0        ,
 71   Z-IN= -22.902   ,  72    THIN=-0.19301   ,  73  PHIN= 0.0       ,  74   PSIN= 0.0        ,  75     DT= 0.10000E-01,
 76     TN=  5.0000   ,  77     KT1=  746.00   ,  78   KT2=  746.00   ,  79    KT3=  956.00    ,  80    KT4=  956.00    ,
 81   RPS1=  59.093   ,  82    RPS2=  59.093   ,  83  RPS3=  59.478   ,  84   RPS4=  59.478    ,  85     B1=-0.30000E-03,
 86     B2= 0.0       ,  87      B3=  1.2000   ,  88    B4= 0.0       ,  89   D1DT= 0.0        ,  90   D2DT= 0.0        ,
 91   D3DT= 0.0       ,  92    DEL1= -1.9000   ,  93  DEL2= -1.3000   ,  94   DEL3= 0.0        ,  95   PHDT= 0.0        ,
 96   PHIR= 0.0       ,  97    DFW1= 0.0       ,  98  DFW2= 0.0       ,  99   U1PR= 0.0        , 100   U2PR= 0.0        ,
101   U3PR= 0.0       , 102    U4PR= 0.0       , 103  S1PR= 0.0       , 104   S2PR= 0.0        , 105   S3PR= 0.0        ,
106   S4PR= 0.0       , 107    PPRT=  1.0000   , 108       = 0.0      , 109        = 0.0       , 110   TQMX= 0.0        ,
111    KTJ= 0.0       , 112      VC= 0.0       , 113  MTSW=  1.0000   , 114   DSWM=  25.000    , 115    TST=  1.0000    ,
116   DSLP= 0.50000   , 117    CGAM=  3.0000   , 118    CS=  3.0000   , 119        = 0.0       , 120        = 0.0       ,
121    PFL=  300.00   , 122      T1= 0.0       , 123   DSW= 0.0       , 124    TSW= 0.0        , 125   ISW5= 0.0        ,
126   SW15= 0.0       , 127    PQSW= 0.0       , 128  VTPS=  3.0000   , 129   VHTP= 0.0        , 130   AMCR= 0.50000E-01,
131    ESP=  18.000   , 132    KSL1= 0.10600E 06, 133  KSL2= 0.10600E 06, 134    AA1=  5.5000   , 135    AA2=  5.5000    ,
136    CCR=  3.7500   , 137    CFCR=  57.000   , 138    AP=  5.7500   , 139    EP1= 0.0        , 140    EP2= 0.0        ,
141   ERR1= 0.0       , 142    ERR2= 0.0       , 143  AML1= 0.0       , 144   AML2= 0.0        , 145   RRIM= 0.0        ,
146        = 0.0      , 147        = 0.0       , 148       = 0.0      , 149        = 0.0       , 150        = 0.0       ,
151        = 0.0      , 152        = 0.0       , 153       = 0.0      , 154        = 0.0       , 155        = 0.0       ,
156        = 0.0      , 157        = 0.0       , 158       = 0.0      , 159        = 0.0       , 160        = 0.0       ,
161        = 0.0      , 162        = 0.0       , 163       = 0.0      , 164        = 0.0       , 165        = 0.0       ,
166        = 0.0      , 167        = 0.0       , 168       = 0.0      , 169    SNT=  73.000    , 170   SNS0=  73.000    ,
171   SNS1=  73.000   , 172    SNSW=  2.0000   , 173  DIST= 0.0       , 174    PL = 0.0        , 175   TSCP= 0.25000    ,
176        = 0.0      , 177        = 0.0       , 178       = 0.0      , 179        =  1.0000   , 180   PASS=  3.0000    ,
181        =  1.0000  , 182     SI1= 0.13000   , 183   SI2= 0.13000   , 184    SI3= 0.20000    , 185    SI4= 0.20000    ,
186        = 0.0      , 187        = 0.0       , 188       = 0.0      , 189        = 0.0       , 190        = 0.0       ,
191        = 0.0      , 192    MTQB=  1.0000   , 193  DRSW= 0.0       , 194    LDF= 0.0        , 195   LDRF= 0.0        ,
196    EK1= 0.0       , 197     EK2= 0.0       , 198  BMPL= 0.0       , 199   BMPS= 0.0        , 200   BMPH=  1.5000    ,
201     XB= 0.0       , 202    APF1= 0.88000   , 203  APF2= 0.0       , 204   APR1= 0.93000    , 205   APR2= 0.0        ,
206   MUSF= 0.64000   , 207    MUSR= 0.70000   , 208       = 0.0      , 209        = 0.0       , 210        = 0.0       ,
211        = 0.0      , 212        = 0.0       , 213       = 0.0      , 214        = 0.0       , 215        = 0.0       ,
216        = 0.0      , 217        = 0.0       , 218       = 0.0      , 219   FEE1= 0.0        , 220   FEE2= 0.0        ,
221   THE1= 0.0       , 222    THE2= 0.0       , 223       = 0.0      , 224        = 0.0       , 225        = 0.0       ,
226        = 0.0      , 227        = 0.0       , 228       = 0.0      , 229        = 0.0       , 230        = 0.0       ,
231     H1=  200.00   , 232      H2=  200.00   , 233       = 0.0      , 234   AKF1=  65.700    , 235   AKF2=  65.700    ,
236   AKF3=  115.00   , 237    AKF4=  115.00   , 238   BR1=  1.4400   , 239    BR2=  1.4400    , 240    BR3=  1.0000    ,
241    BR4=  1.0000   , 242     KCF=-0.40700E-04, 243  KCR=-0.24100E-04, 244   KSR= 0.21800E-05, 245   RB1=-0.86800E-04,
246    RB2= 0.0       , 247     RB3=  1.1850   , 248   RB4=-0.13400E-06, 249  AFK1=-0.59300E-02, 250   AFK2= 0.61200E-02,
251   AFK3=  1.5710   , 252    ARK1=-0.44500E-02, 253  ARK2= 0.44000E-02, 254   ARK3= 0.68850   , 255   OFC0= 0.0        ,
256   OFC1=-0.24500E-02, 257   DFC2=-0.53700E-02, 258  DFC3=-0.81100  , 259   DRC0= 0.0        , 260   DRC1=-0.18400E-02,
261   DRC2=-0.50300E-02, 262   DRC3= -1.8500   , 263  CP0F= 0.0       , 264   CP1F= 0.30000E-01, 265   CP2F= 0.0        ,
266   CP0R= 0.29000   , 267    CP1R= 0.30000E-01, 268  CP2R= 0.0       , 269   CH0F= 0.89000E-01, 270   CR1F= 0.10000E-01,
271   CR2F= 0.0       , 272    CR0R= 0.13000   , 273  CR1R= 0.30000E-01, 274   CR2R= 0.0       , 275        = 0.0       ,
276        = 0.0      , 277    BMPN= 0.0       , 278  TQB0= 0.0       , 279   TQB1= 0.0        , 280        = 0.0       ,
281        =  1.0000  , 282        =  1.0000   , 283       = 0.0      , 284    HFC=  2.4000    , 285    HRC=  3.4000    ,
286        = 0.0      , 287    AXLE=  2.0000   , 288       = 0.0      , 289        = 0.0       , 290    ROT =  1.0000   ,
291    RA0 =  4037.0  , 292     RA1 =  3.8700  , 293   RA2 =  1728.0  , 294    RA3 =  1.4100   , 295    RA4 =  3902.0   ,
```

```
PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 PONTIAC TRANS. AM
  1      MS=  9.2700     ,   2     MUF= 0.53000     ,   3     MUR= 0.86000     ,   4      ZF=  6.7000     ,   5      ZR=  6.7000     ,
  6       A=  42.250     ,   7       B=  65.750     ,   8      TF=  61.900     ,   9      TR=  60.400     ,  10      TS=  45.500     ,
 11      IX=  3724.0     ,  12      IY=  20199.     ,  13      IZ=  21291.     ,  14     IXZ=  230.00     ,  15      IR=  530.00     ,
 16      CF= 0.0         ,  17      RF= 0.35600E 06,  18    CFPR=  35.000     ,  19      KF=  99.000     ,  20    LAMF=  2.0000     ,
 21    DMFC= -2.0000     ,  22    DMFT=  2.5000     ,  23      CR= 0.0         ,  24      RR= 0.19000E 06,  25    CRPR=  55.000     ,
 26      KR=  147.00     ,  27    LAMR=  2.0000     ,  28    DMRC= -3.3000     ,  29    DMRT=  3.7000     ,  30     KRS=-0.80000E-02,
 31      RW=  12.800     ,  32        = 0.0         ,  33     FOT=  1.0000     ,  34      A0= -401.85     ,  35      A1=  19.080     ,
 36      A2=  3143.0     ,  37      A3=  2.8200     ,  38      A4=  4737.0     ,  39        = 0.0         ,  40        =  1.0700     ,
 41     KSC=  8000.0     ,  42      NG=  15.500     ,  43    LAFC=  2.0000     ,  44    LAFT=  3.5000     ,  45    LARC=  2.0000     ,
 46    LART=  5.0000     ,  47     IFW=  8.0000     ,  48        = 0.0         ,  49     IWF=  10.000     ,  50     IWR=  10.000     ,
 51      ID= 0.70000     ,  52      AR=  3.4200     ,  53        = 0.0         ,  54        = 0.0         ,  55      PT=-0.24000     ,
 56    YSA1=  5.0000     ,  57    YSA2= -5.0000     ,  58    PHS1=-0.15270     ,  59    PHS2= 0.15270     ,  60    CTSW=  1.0000     ,
 61        = 0.0         ,  62        = 0.0         ,  63    P-IN= 0.0         ,  64    Q-IN= 0.0         ,  65    R-IN= 0.0         ,
 66    U-IN=  40.000     ,  67    V-IN= 0.0         ,  68    W-IN= 0.0         ,  69    X-IN= 0.0         ,  70    Y-IN= 0.0         ,
 71    Z-IN= -18.886     ,  72    THIN=-0.99608E-01,  73    PHIN= 0.0         ,  74    PSIN= 0.0         ,  75      DT= 0.10000E-01,
 76      TN=  5.0000     ,  77     KT1=  1736.0     ,  78     KT2=  1736.0     ,  79     KT3=  1736.0     ,  80     KT4=  1736.0     ,
 81    RPS1=  58.120     ,  82    RPS2=  58.120     ,  83    RPS3=  57.233     ,  84    RPS4=  57.233     ,  85      B1=-0.39800E-03,
 86      B2= 0.0         ,  87      B3=  1.3250     ,  88      B4= 0.94000E-07,  89    D1DT= 0.0         ,  90    D2DT= 0.0         ,
 91    D3DT= 0.0         ,  92    DEL1= -1.3000     ,  93    DEL2=-0.79000     ,  94    DEL3= 0.0         ,  95    PHDT= 0.0         ,
 96    PHIR= 0.0         ,  97    DFW1= 0.0         ,  98    DFW2= 0.0         ,  99    U1PR= 0.0         , 100    U2PR= 0.0         ,
101    U3PR= 0.0         , 102    U4PR= 0.0         , 103    S1PR= 0.0         , 104    S2PR= 0.0         , 105    S3PR= 0.0         ,
106    S4PR= 0.0         , 107    PPRT=  1.0000     , 108        = 0.0         , 109        = 0.0         , 110    TQMX= 0.0         ,
111     KTJ= 0.0         , 112      VC= 0.0         , 113    MTSW=  1.0000     , 114    DSWM=  25.000     , 115     TST=  1.0000     ,
116    DSLP= 0.50000     , 117    CGAM=  3.0000     , 118      CS=  3.0000     , 119        = 0.0         , 120        = 0.0         ,
121     PFL=  300.00     , 122      T1= 0.0         , 123     DSW= 0.0         , 124     TSW= 0.0         , 125    ISWS= 0.0         ,
126    SW15= 0.0         , 127    POSW= 0.0         , 128    VTPS=  3.0000     , 129    VHTP= 0.0         , 130    AMCR= 0.60000E-01,
131     ESP=  14.000     , 132    KSL1=  87000.     , 133    KSL2=  87000.     , 134     AA1=  6.2600     , 135     AA2=  6.2600     ,
136     CCR=  11.000     , 137    CFCR=  69.000     , 138      AP=  5.8700     , 139     EP1= 0.67000     , 140     EP2=-0.67000     ,
141    ERR1= 0.0         , 142    ERR2= 0.0         , 143    AML1= 0.0         , 144    AML2= 0.0         , 145    RRIM= 0.0         ,
146        = 0.0         , 147        = 0.0         , 148        = 0.0         , 149        = 0.0         , 150        = 0.0         ,
151        = 0.0         , 152        = 0.0         , 153        = 0.0         , 154        = 0.0         , 155        = 0.0         ,
156        = 0.0         , 157        = 0.0         , 158        = 0.0         , 159        = 0.0         , 160        = 0.0         ,
161        = 0.0         , 162        = 0.0         , 163        = 0.0         , 164        = 0.0         , 165        = 0.0         ,
166        = 0.0         , 167        = 0.0         , 168        = 0.0         , 169     SNT=  73.000     , 170    SN50=  73.000     ,
171    SNS1=  73.000     , 172    SNSW=  2.0000     , 173    DIST= 0.0         , 174     PL = 0.0         , 175    TSCP= 0.25000     ,
176        = 0.0         , 177        = 0.0         , 178        = 0.0         , 179        =  1.0000     , 180    PASS=  3.0000     ,
181        =  1.0000     , 182     SI1= 0.14000     , 183     SI2= 0.14000     , 184     SI3= 0.14000     , 185     SI4= 0.14000     ,
186        = 0.0         , 187        = 0.0         , 188        = 0.0         , 189        = 0.0         , 190        = 0.0         ,
191        = 0.0         , 192    MTQB=  1.0000     , 193    DRSW= 0.0         , 194     LDF= 0.0         , 195    LDRF= 0.0         ,
196     EK1= 0.0         , 197     EK2= 0.0         , 198    BMPL= 0.0         , 199    BMPS= 0.0         , 200    BMPH=  1.5000     ,
201      XB= 0.0         , 202    APF1=  1.0900     , 203    APF2= 0.0         , 204    APR1=  1.0900     , 205    APR2= 0.0         ,
206    MUSF= 0.79000     , 207    MUSR= 0.79000     , 208        = 0.0         , 209        = 0.0         , 210        = 0.0         ,
211        = 0.0         , 212        = 0.0         , 213        = 0.0         , 214        = 0.0         , 215        = 0.0         ,
216        = 0.0         , 217        = 0.0         , 218        = 0.0         , 219    FEE1= 0.0         , 220    FEE2= 0.0         ,
221    THE1= 0.0         , 222    THE2= 0.0         , 223        = 0.0         , 224        = 0.0         , 225        = 0.0         ,
226        = 0.0         , 227        = 0.0         , 228        = 0.0         , 229        = 0.0         , 230        = 0.0         ,
231      H1=  400.00     , 232      H2=  400.00     , 233        = 0.0         , 234    AKF1=  99.000     , 235    AKF2=  99.000     ,
236    AKF3=  147.00     , 237    AKF4=  147.00     , 238     BR1=  1.6700     , 239     BR2=  1.6700     , 240     BR3=  1.0000     ,
241     BR4=  1.0000     , 242     KCF=-0.28100E-04, 243     KCR=-0.34600E-04, 244     KSR= 0.26200E-05, 245     RB1=-0.39800E-03,
246     RB2= 0.0         , 247     RB3=  1.3250     , 248     RB4= 0.94000E-07, 249    AFK1=-0.27960E-02, 250    AFK2= 0.28200E-02,
251    AFK3=  2.2980     , 252    ARK1=-0.27960E-02, 253    ARK2= 0.28200E-02, 254    ARK3=  2.2980     , 255    DFC0= 0.0         ,
256    DFC1=-0.89760E-03, 257    DFC2=-0.41900E-02, 258    DFC3= -10.040     , 259    DRC0= 0.0         , 260    DRC1=-0.89760E-03,
261    DRC2=-0.41900E-02, 262    DRC3= -10.040     , 263    CP0F=-0.90000E-01, 264    CP1F=-0.30000E-01, 265    CP2F= 0.0         ,
266    CP0R= 0.15000     , 267    CP1R= 0.15000E-01, 268    CP2R= 0.0         , 269    CR0F= 0.64000E-01, 270    CR1F= 0.10000E-01,
271    CR2F= 0.0         , 272    CR0R= 0.0         , 273    CR1R= 0.0         , 274    CR2R= 0.0         , 275        = 0.0         ,
276        = 0.0         , 277    PMPN= 0.0         , 278    TQB0= 0.0         , 279    TQB1= 0.0         , 280        = 0.0         ,
281        =  1.0000     , 282        =  1.0000     , 283        = 0.0         , 284     HFC=  2.0000     , 285     HRC=  5.7000     ,
286        = 0.0         , 287    AXLE=  1.0000     , 288        = 0.0         , 289        = 0.0         , 290     RDT =  1.0000     ,
291     RA0 = -401.85    , 292     RA1 =  19.080    , 293     RA2 =  3143.0    , 294     RA3 =  2.8200    , 295     RA4 =  4737.0    ,
```

APPENDIX F

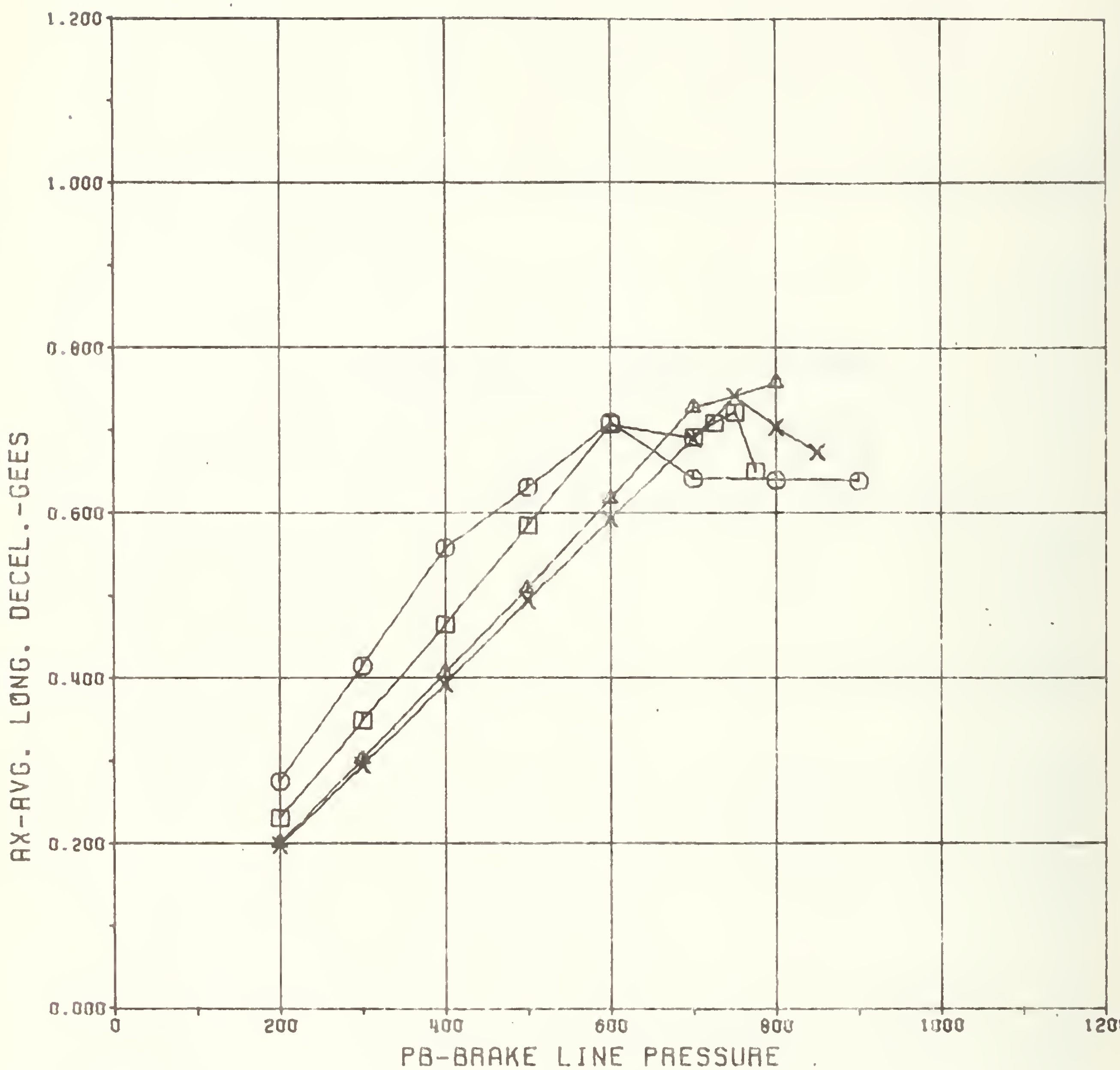
COMPARISON VARIABLE GRAPHS

1. VHTP #1 - STRAIGHT LINE BRAKING

A_x - Average Longitudinal Deceleration from 35 mph to 10 mph (GEES)

P_B - Brake Line Pressure (PSI)

*** AVG. LONG. DECEL. VS. BRAKE LINE PRESSURE ***
(CALSPAN, O.E. TIRES, STRIGHT LINE BRAKING)



- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE

15 JUL 74

2. VHTP #2 - BRAKING IN A TURN

A_x - Average Longitudinal Deceleration from 35 mph to 10 mph (GEES)

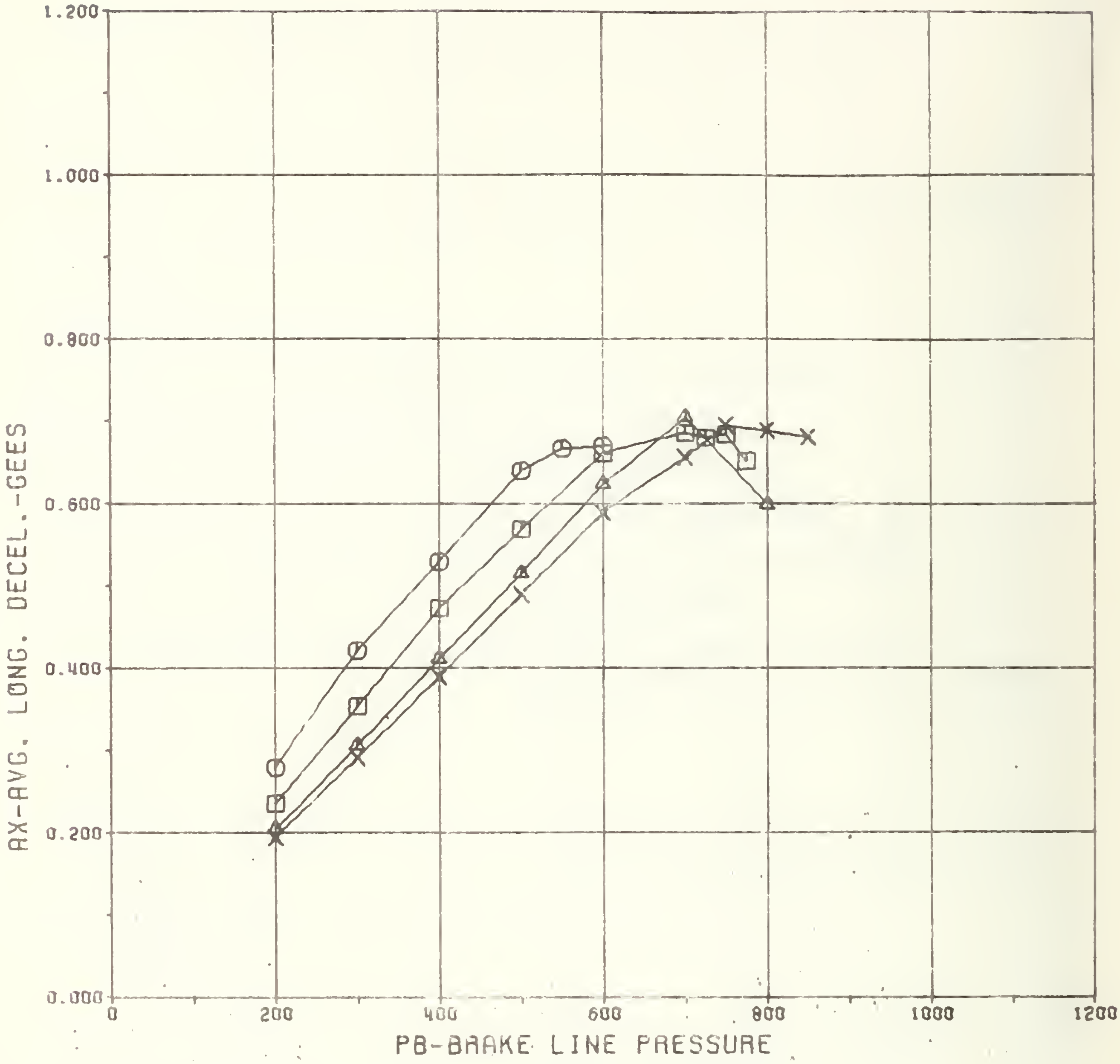
P_B - Brake Line Pressure (PSI)

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

$R_0(1/R)$ - Average Path Curvature Ratio Relative to Initial Turn

*** AVG. LONG. DECEL. VS. BRAKE LINE PRESSURE ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)



⊙ - DODGE CORONET

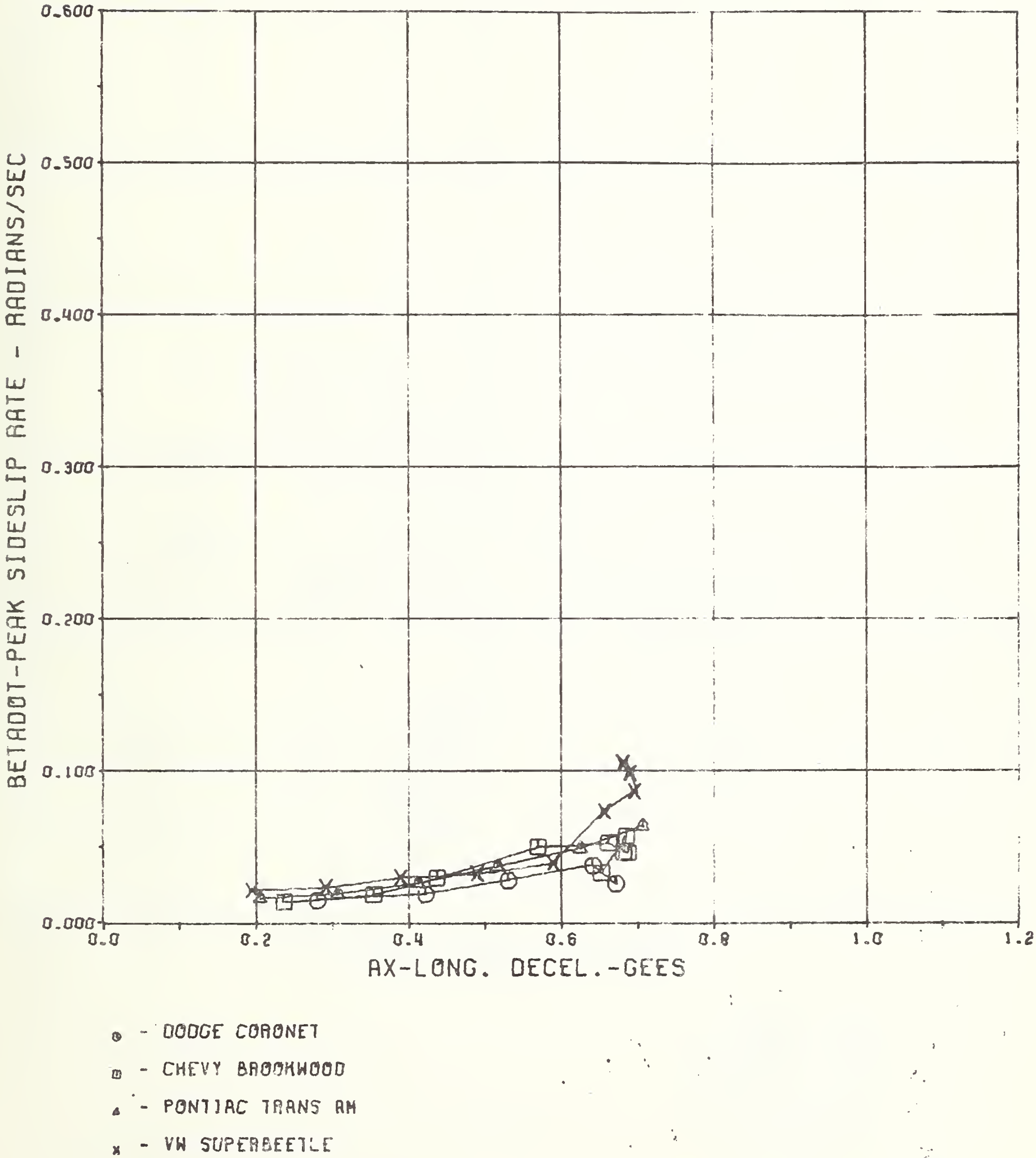
⊡ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

✕ - VW SUPERBEETLE

15 JUL 74

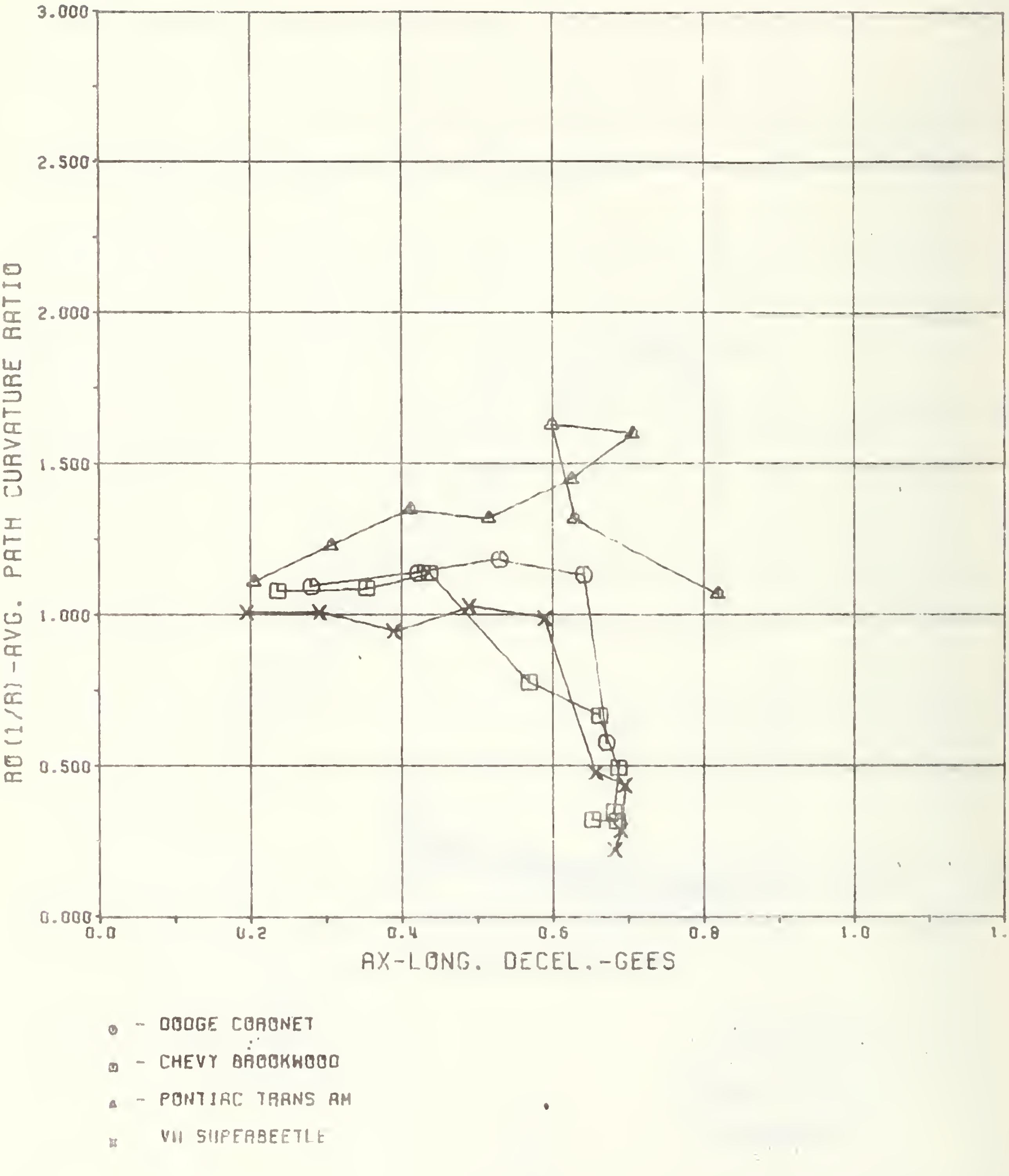
*** SIDESLIP RATE VS. AVG. LONG. DECEL. ***
(CALSPAN, O.E. TIRES, BRAKING IN A TURN)



16 JUL 74

*** AVG. PATH CURV. RATIO VS. AVG. LONG. DECEL. ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)



15 JUL 74

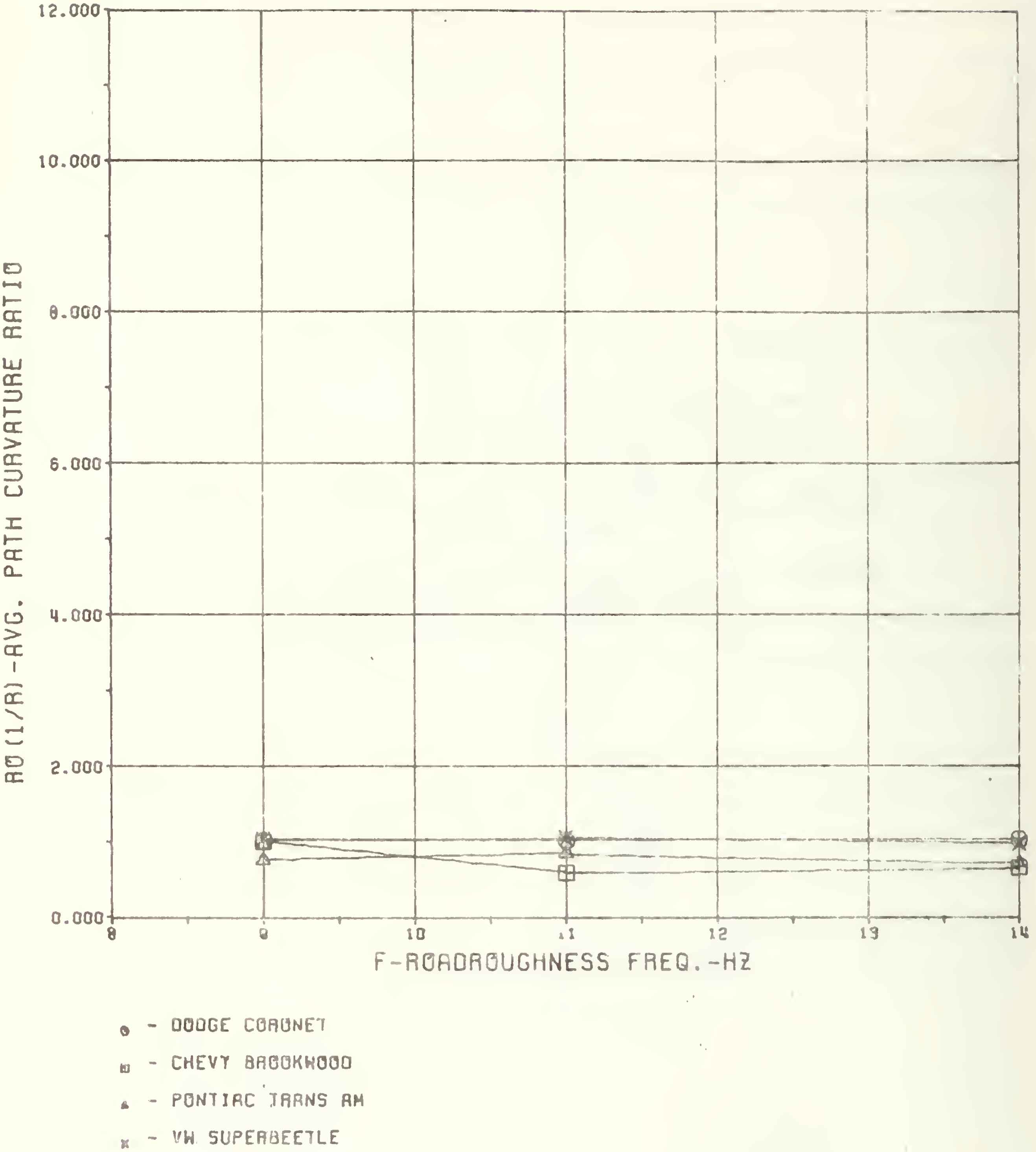
3. VHTP #3 - TURNING ON A ROUGH ROAD

f - Roadroughness Fundamental Frequency - Determined by Spacing of the Disturbance Elements in Each Grid (HZ)

$R_0(1/R)$ - Average Path Curvature Ratio Relative to the Initial Turn

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

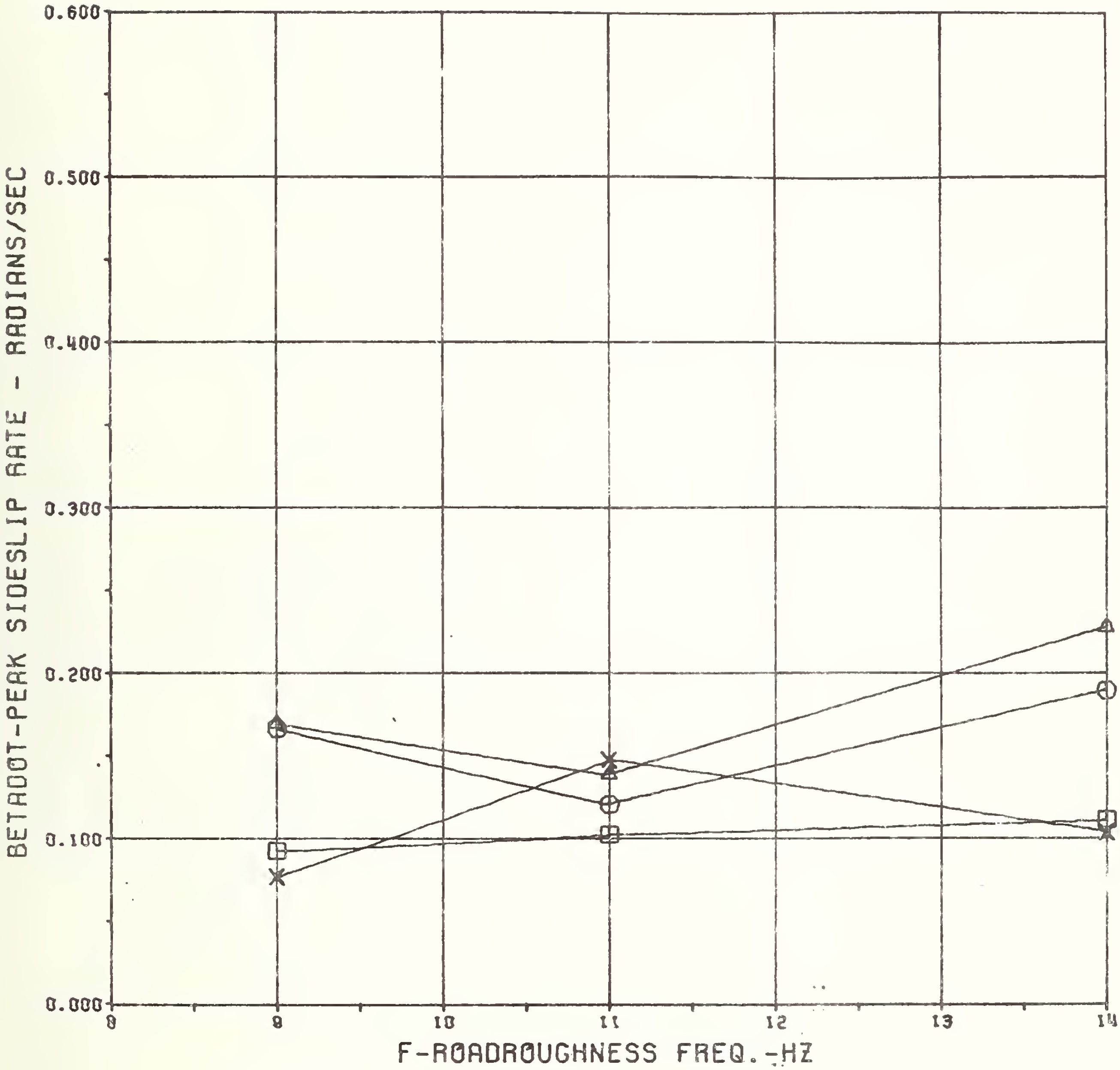
*** AVG. PATH CURVATURE RATIO VS. ROADROUGHNESS FREQ. ***
(CALSPAN, O.E. TIRES, TURNING ON A ROUGH ROAD)



15 JUL 74

*** SIDESLIP RATE VS. ROADROUGHNESS FREQ. ***

(CALSPAN, O.E. TIRES, TURNING ON A ROUGH ROAD)



⊙ - DODGE CORONET

⊡ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

✕ - VW SUPERBEETLE

15 JUL 74

4. VHTP #4 - TRAPEZOIDAL STEER

A_y - Peak Lateral Acceleration (GEES)

SIGMA - Normalized Steer Angle (DEGREES)

R - Peak Yaw Rate (RADIANS/SEC)

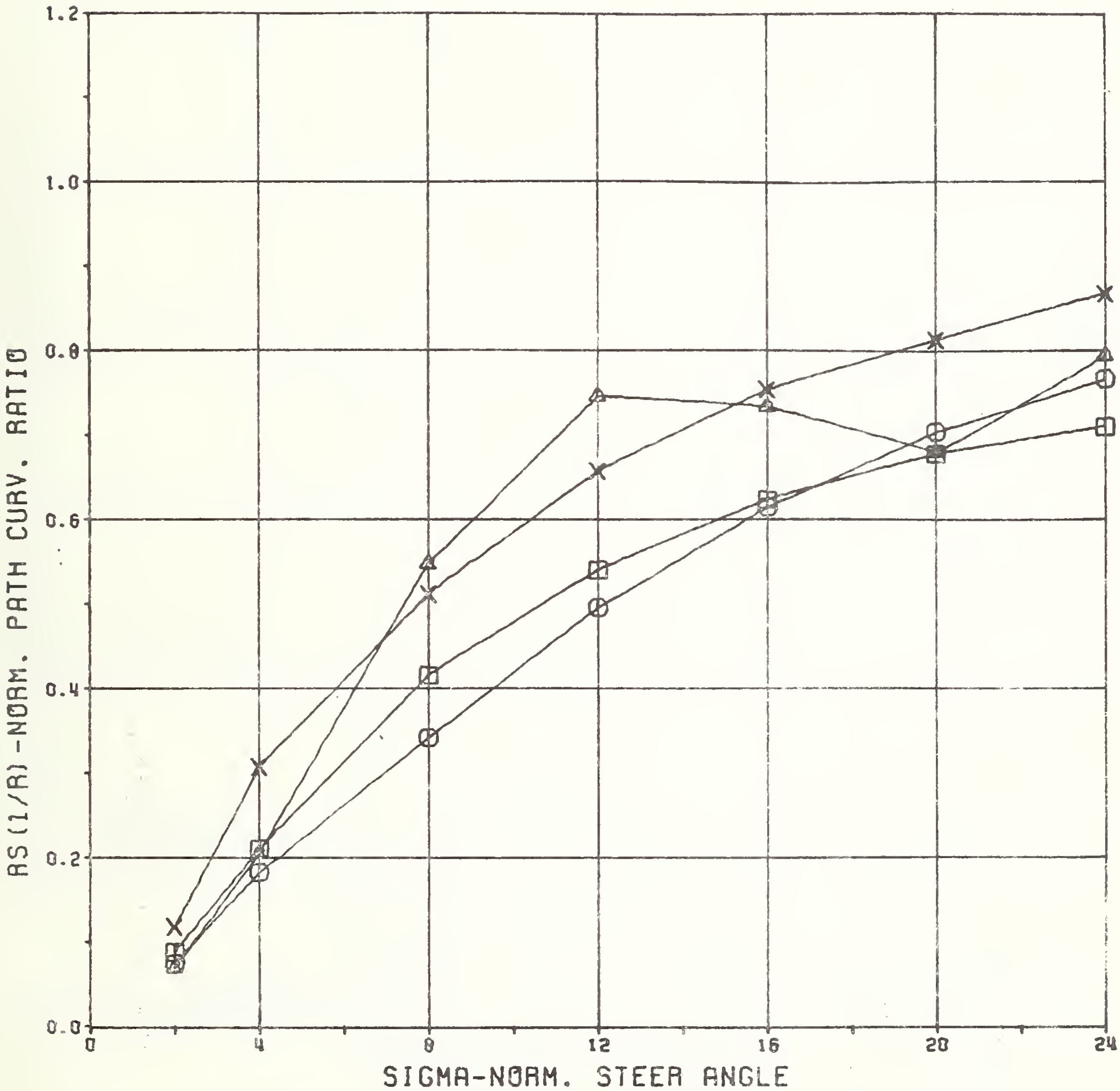
$R_s(1/R)$ - Path Curvature Response Averaged Over Two Seconds and Ratioed to a Reference Path Curvature Deriving from a Steady Turn of 40 mph and 1.0g A_y

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

BETA - Peak Vehicle Sideslip Angle (RADIANS)

*** NORM. CURVATURE RATIO VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)

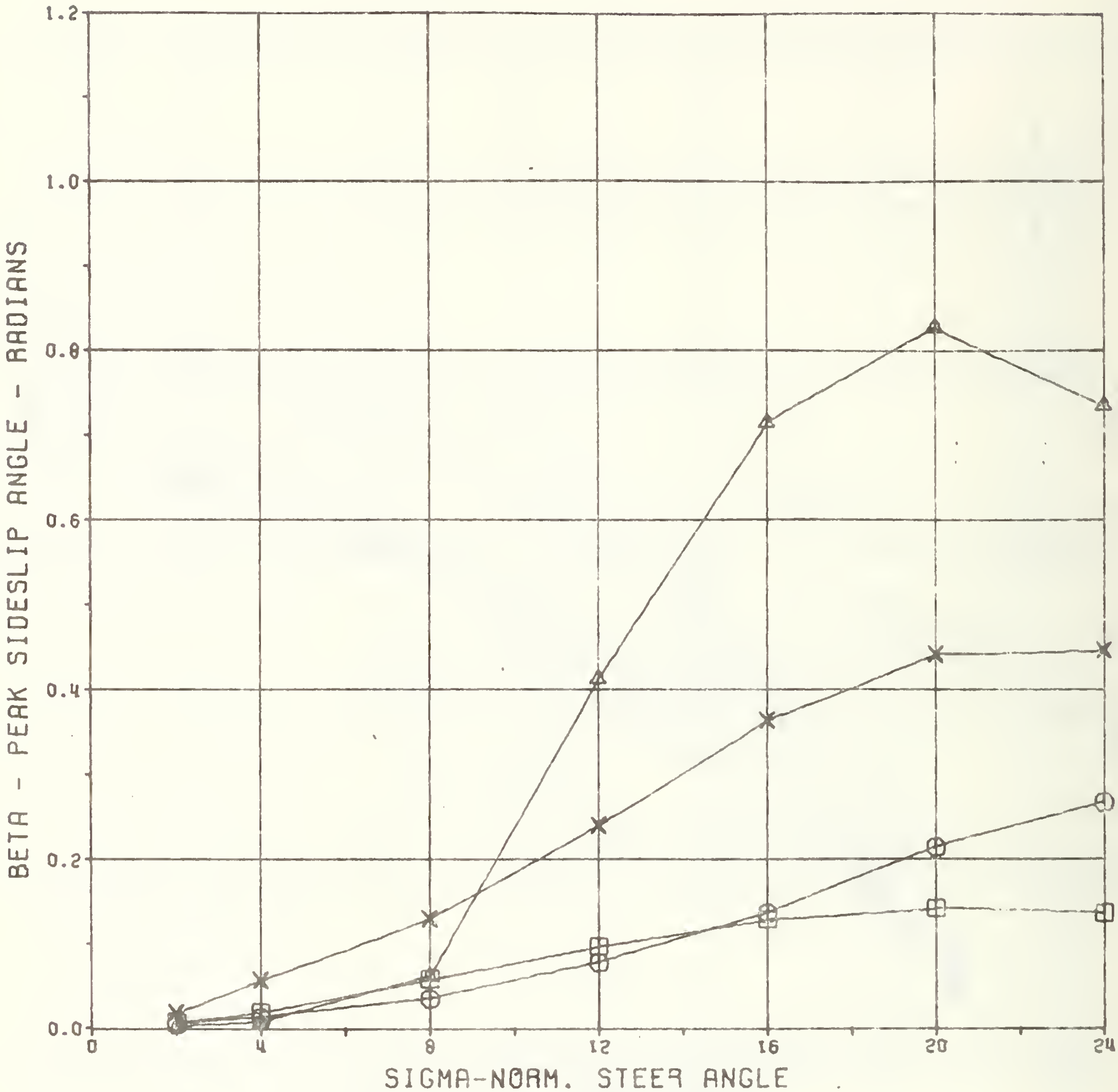


- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE

15 JUL 74

*** SIDESLIP ANGLE VERSUS NORMALIZED STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



⊕ - DODGE CORONET

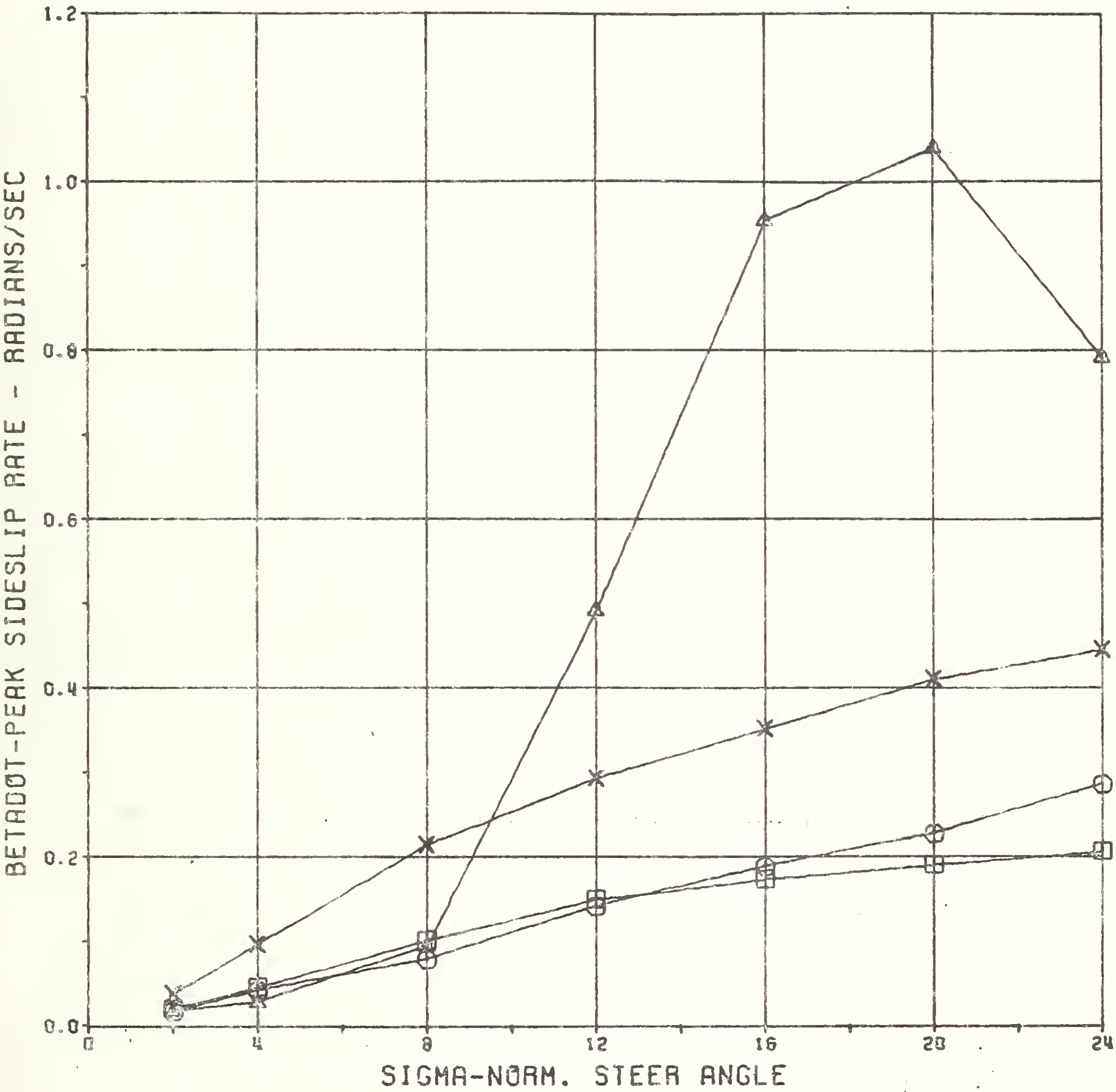
⊞ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

✕ - VW SUPERBEETLE

15-JUL 74

*** SIDESLIP RATE VERSUS NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



○ - DODGE CORONET

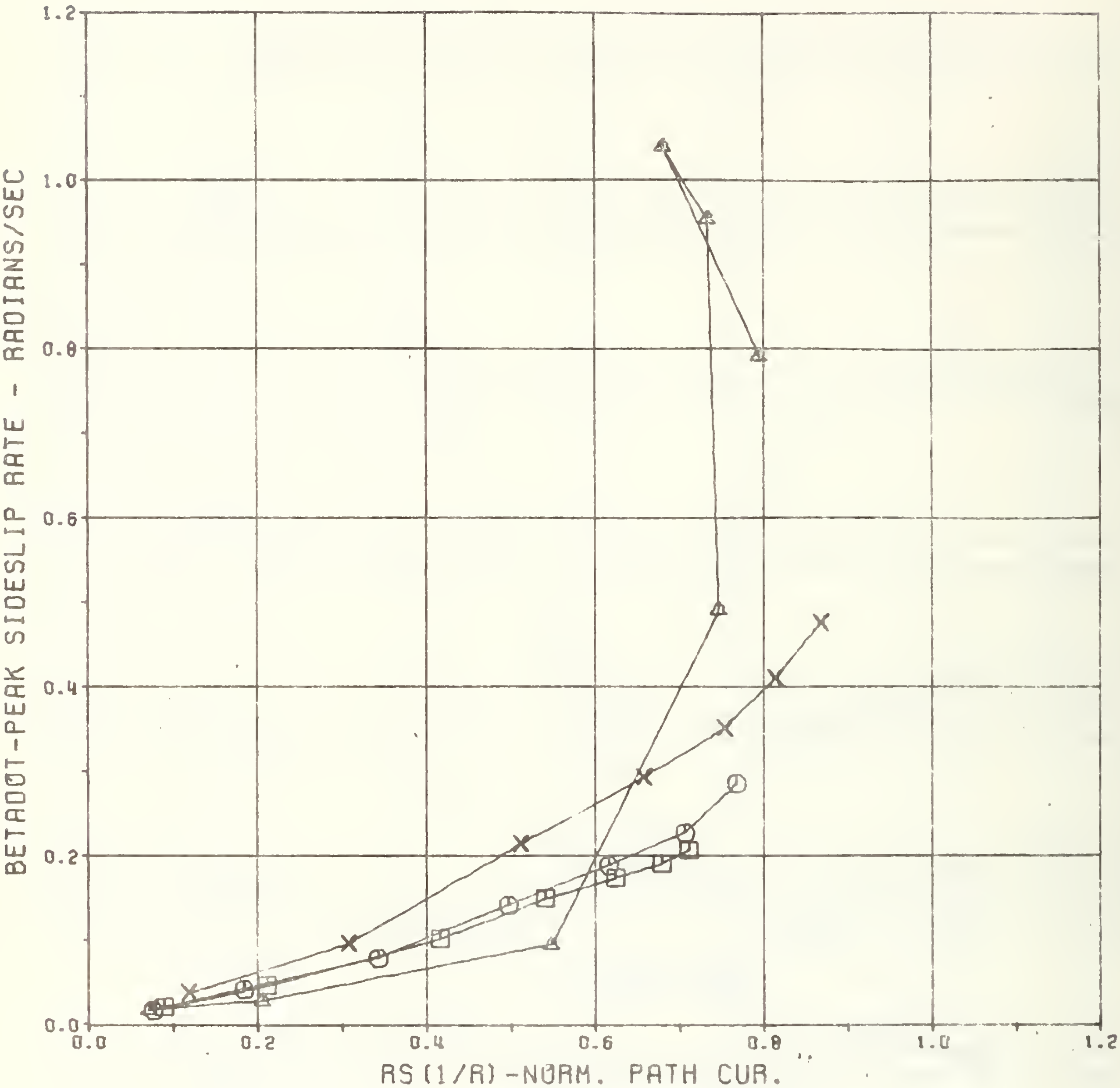
□ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

× - VW SUPERBEETLE

*** SIDESLIP RATE VERSUS NORM. PATH CURVATURE RATIO ***

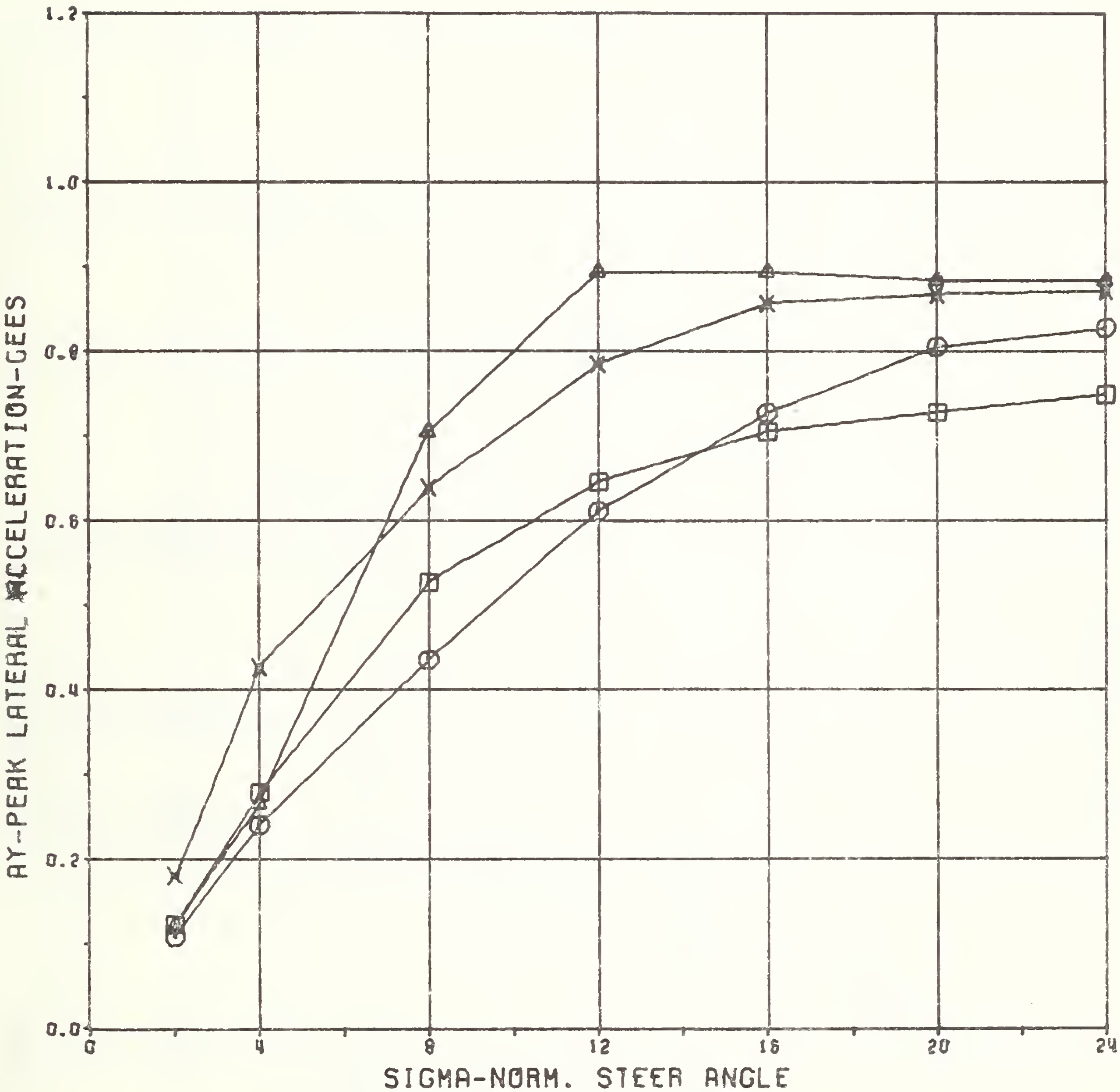
(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



15 JUL 74

*** LATERAL ACCECERATION VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



o - DODGE CORONET

▫ - CHEVY BROOKWOOD

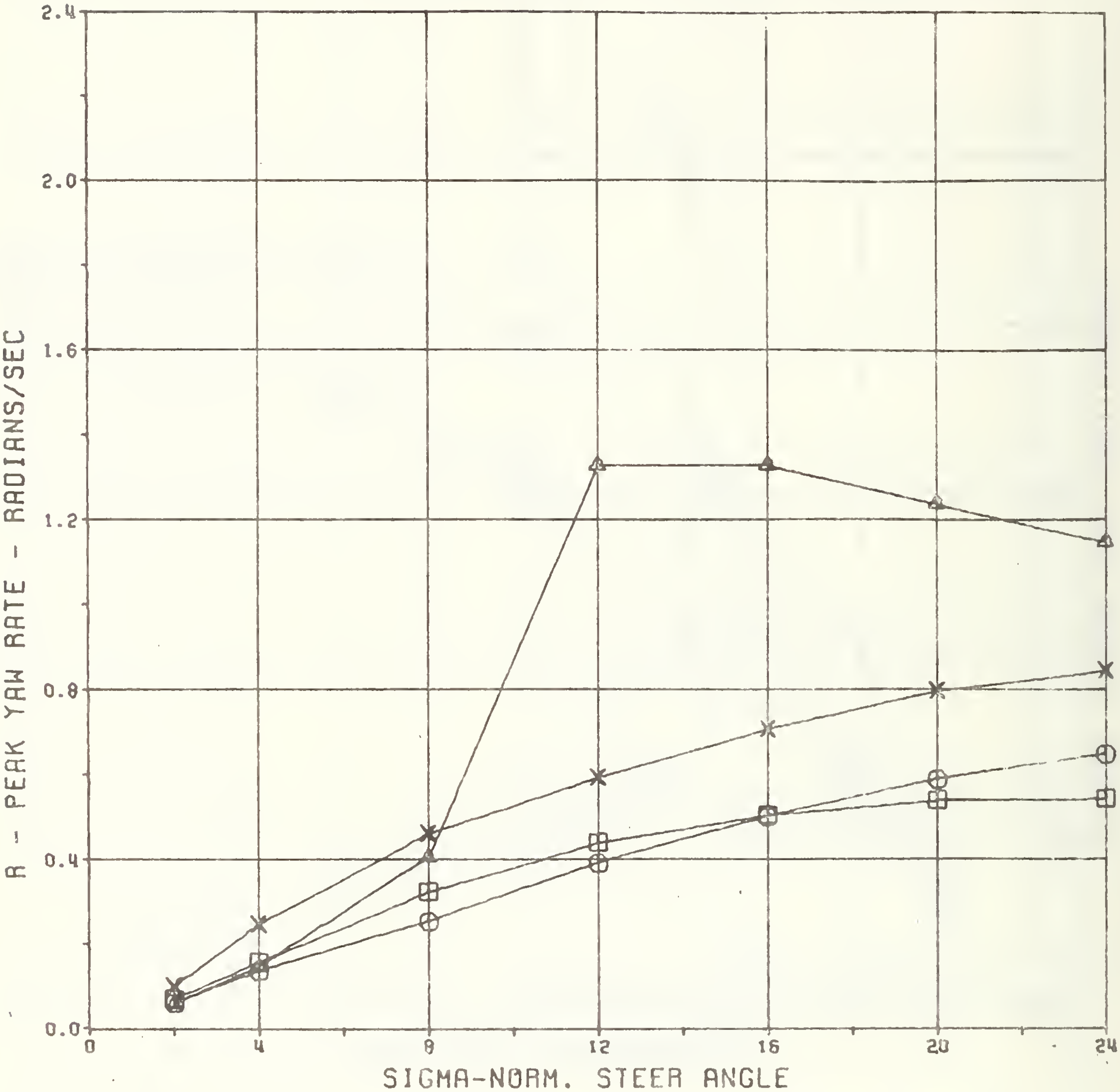
▵ - PONTIAC TRANS AM

* - VW SUPERBEETLE

16 JUL 74

*** YAW RATE VERSUS NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



○ - DODGE CORONET

□ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

× - VW SUPERBEETLE

15 JUL 74

5. VHTP #5 - SINUSOIDAL STEER

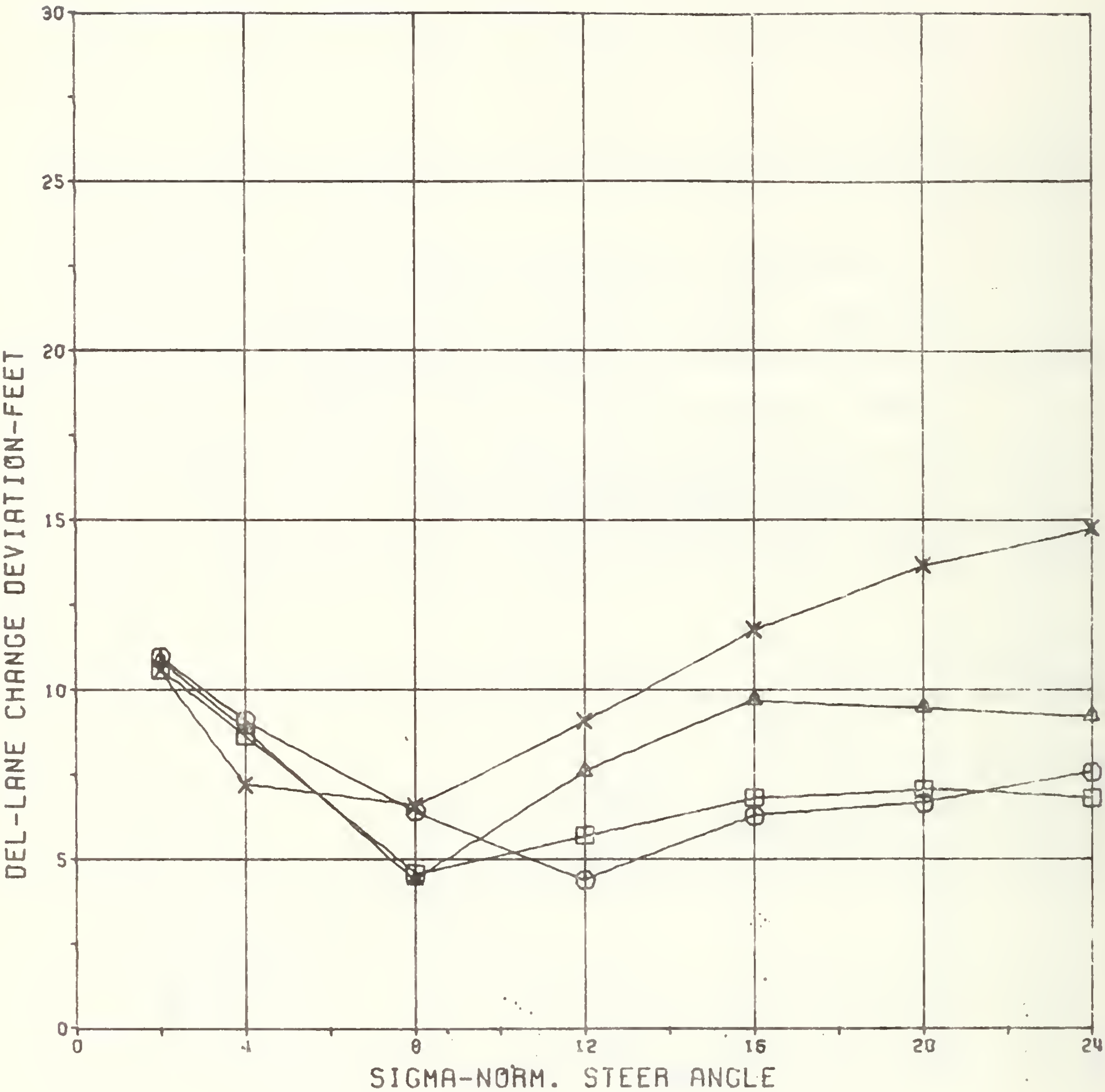
DEL PSI - Vehicle Heading Angle Deviation After 3.4 Seconds (RADIANS)

SIGMA - Normalized Steer Angle (DEGREES)

DEL - Lane Change Deviation from "IDEAL" Lane Change Displacement (FEET)

BETA - Peak Vehicle Sideslip Angle (RADIANS)

*** LANE CHANGE DEV. VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)

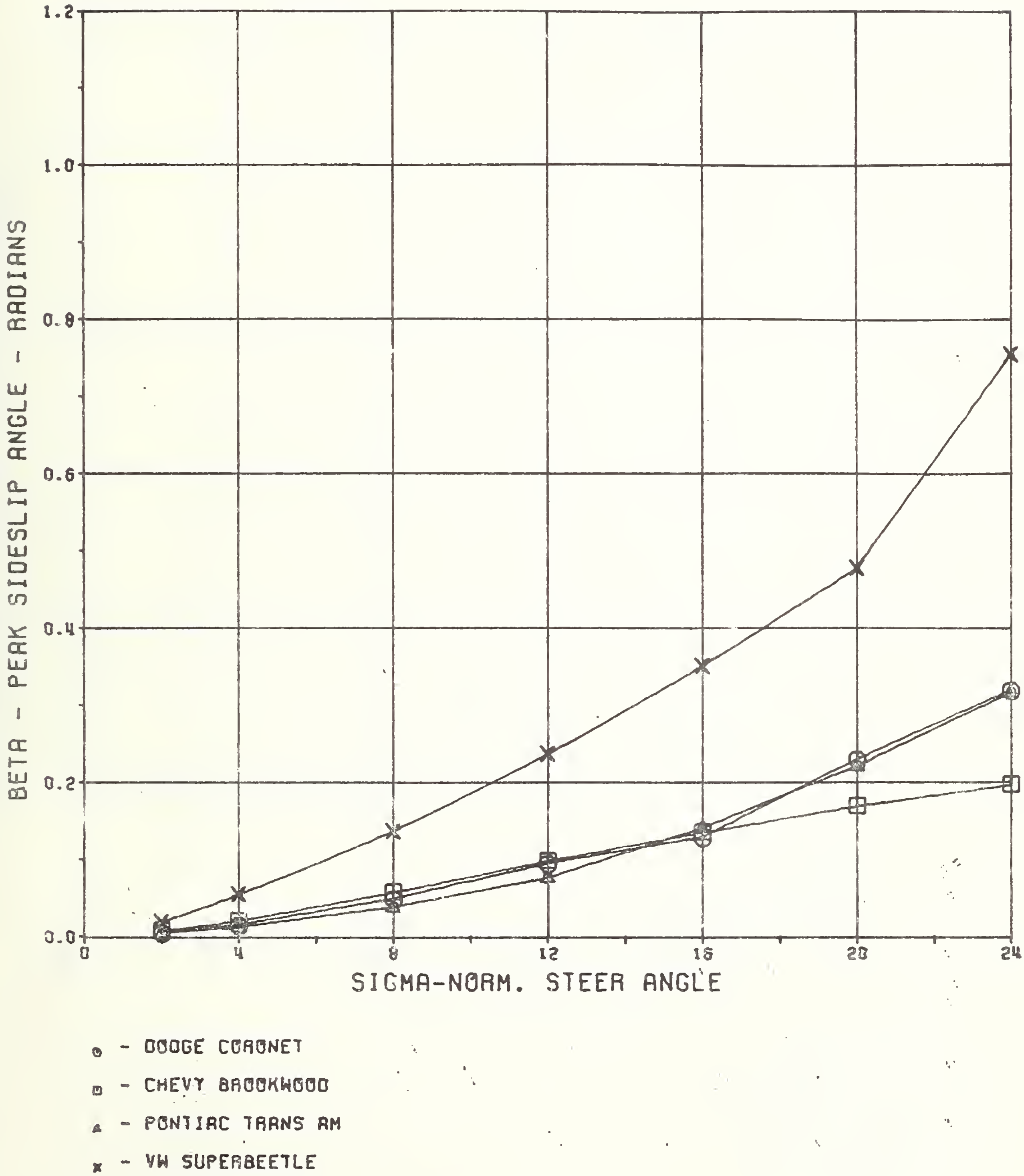


⊙ - DODGE CORONET
⊡ - CHEVY BROOKWOOD
▲ - PONTIAC TRANS AM
x - VW SUPERBEETLE

15 JUL 74

*** SIDESLIP ANGLE VS. NORM. STEER ANGLE ***

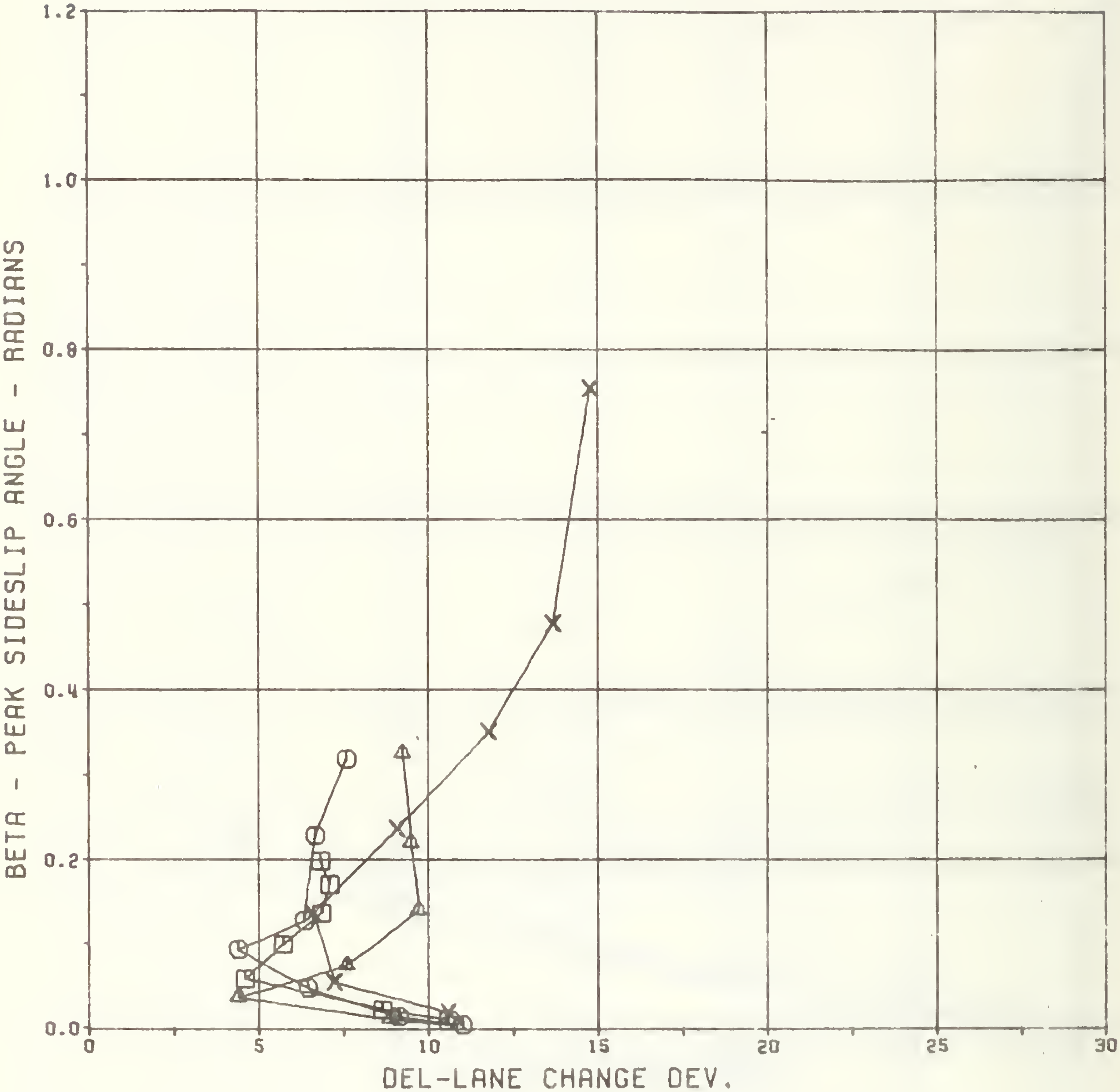
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)



15 JUL 74

*** SIDESLIP ANGLE VS. LANE CHANGE DEV. ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)



○ - DODGE CORONET

□ - CHEVY BROOKWOOD

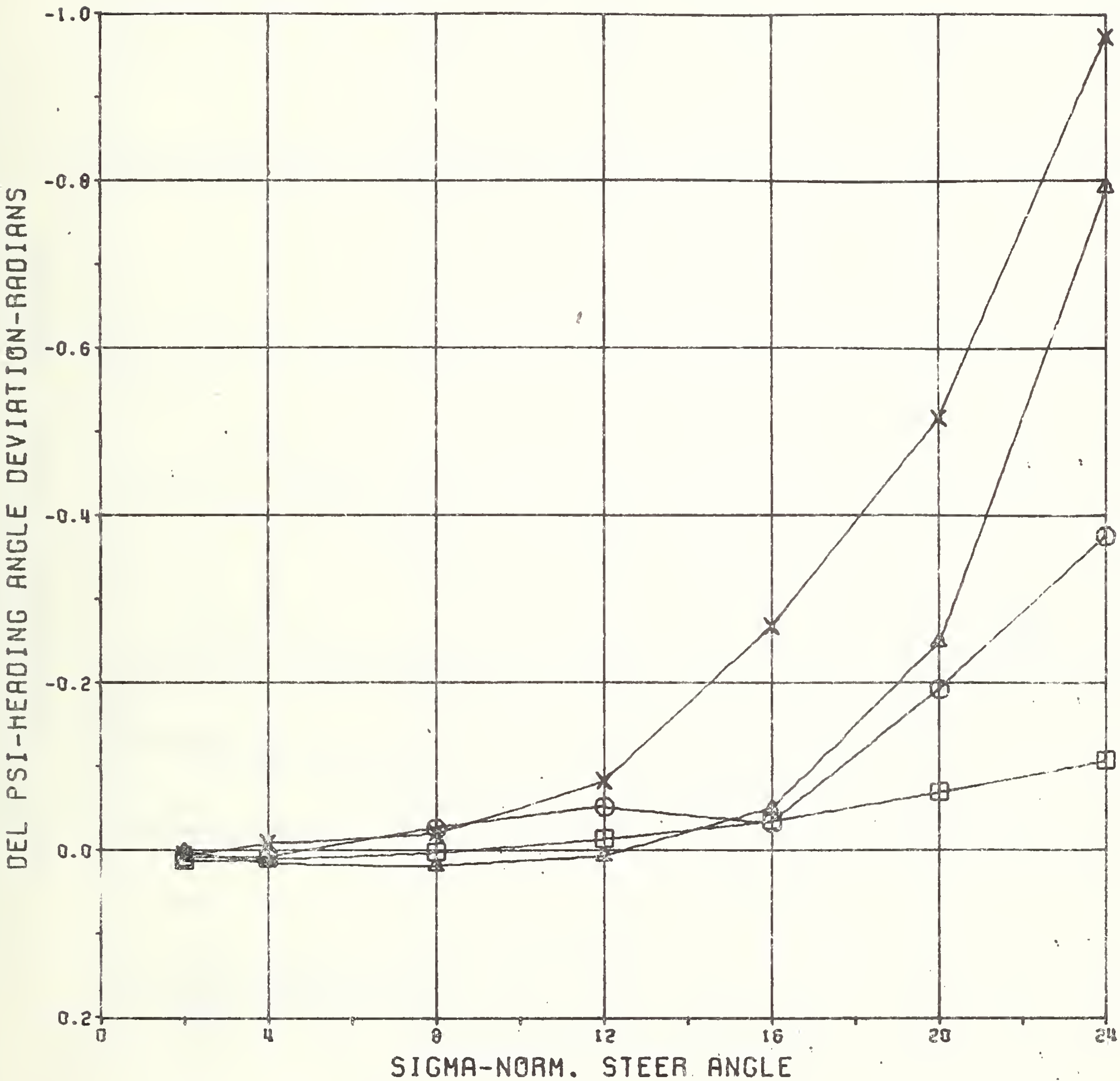
△ - PONTIAC TRANS AM

× - VW SUPERBEETLE

15 JUL 74

*** HEADING ANGLE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)



o - DODGE CORONET

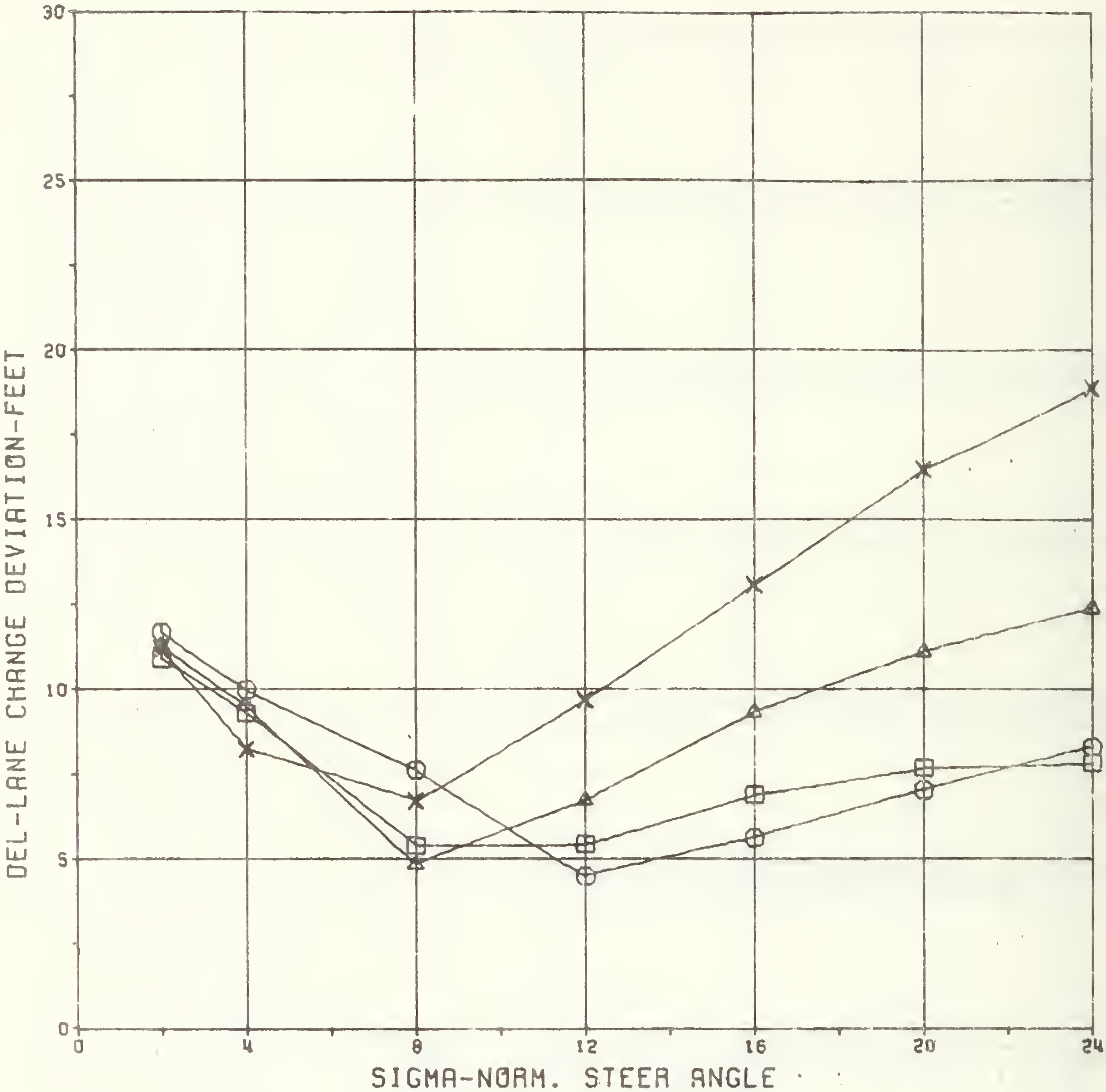
□ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

x - VW SUPERBEETLE

15 JUL 74

*** LANE CHANGE DEV. VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



○ - DODGE CORONET

□ - CHEVY BROOKWOOD

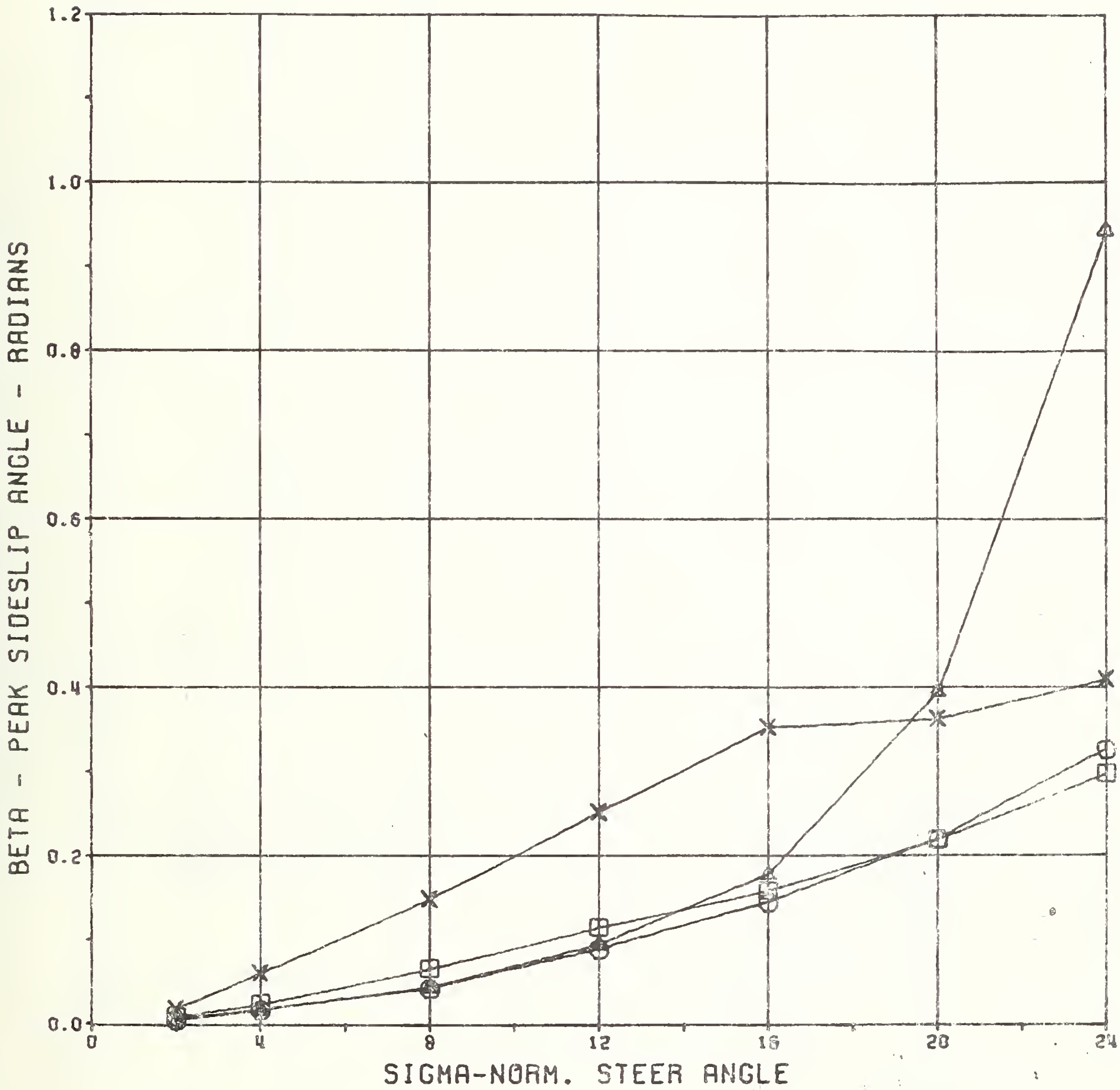
▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

15 JUL 74

*** SIDESLIP ANGLE VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



○ - DODGE CORONET

□ - CHEVY BROOKWOOD

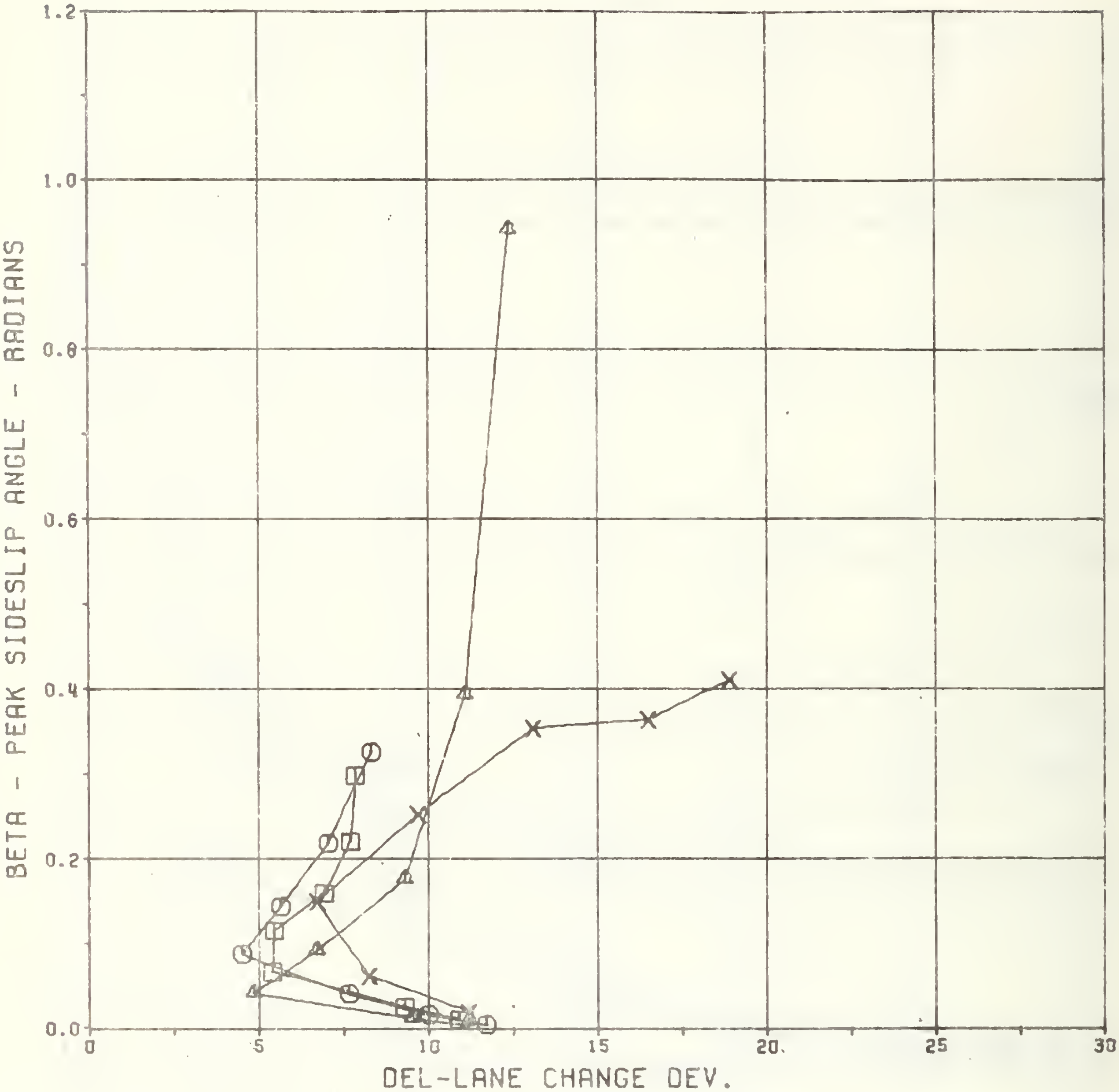
△ - PONTIAC TRANS AM

× - VW SUPERBEETLE

15 JUL 74

*** SIDESLIP ANGLE VS. LANE CHANGE DEV. ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



○ - DODGE CORONET

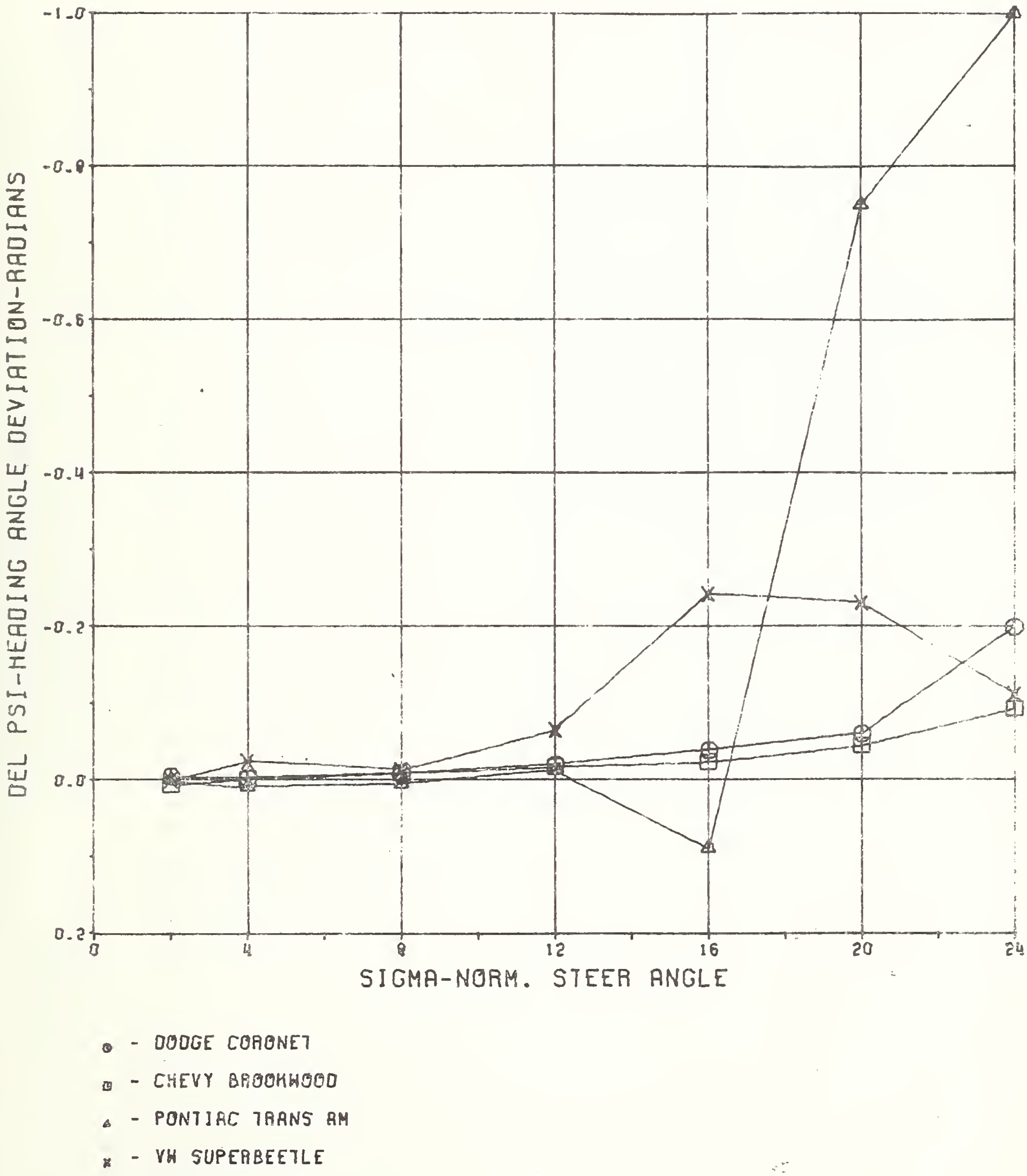
□ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

× - VW SUPERBEETLE

15 JUL 74

*** HEADING ANGLE DEV. VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



16 JUL 74

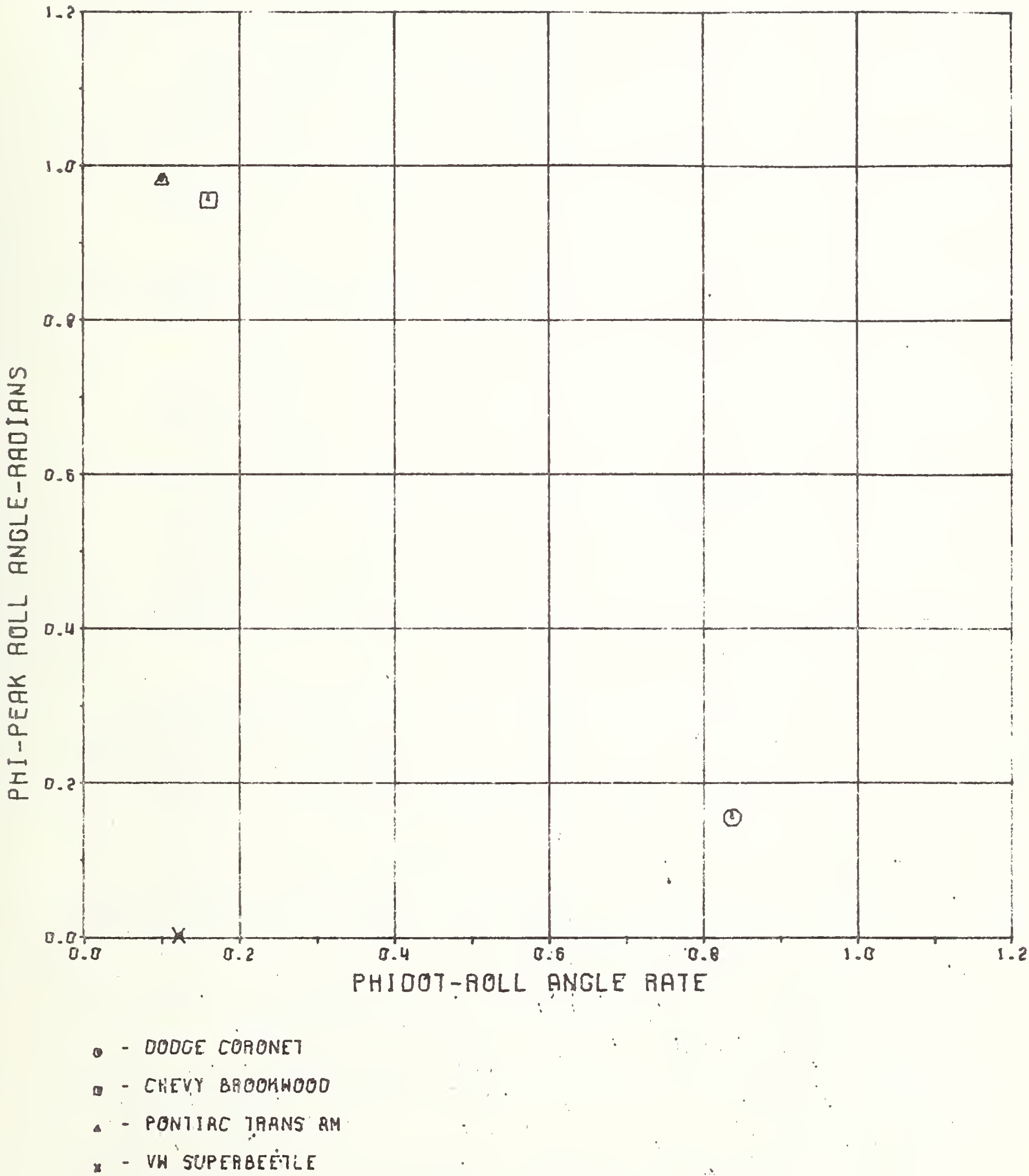
6. VHTP #6 - DRASTIC STEER AND BRAKE

PHI - Peak Roll Angle (RADIANS)

PHIDOT - Peak Roll Angle Rate (RADIANS/SEC)

*** ROLL ANGLE VS. ROLL ANGLE RATE ***

(CALSPAN, O.E. TIRES, DRASTIC STEER & BRAKE-50 MPH)



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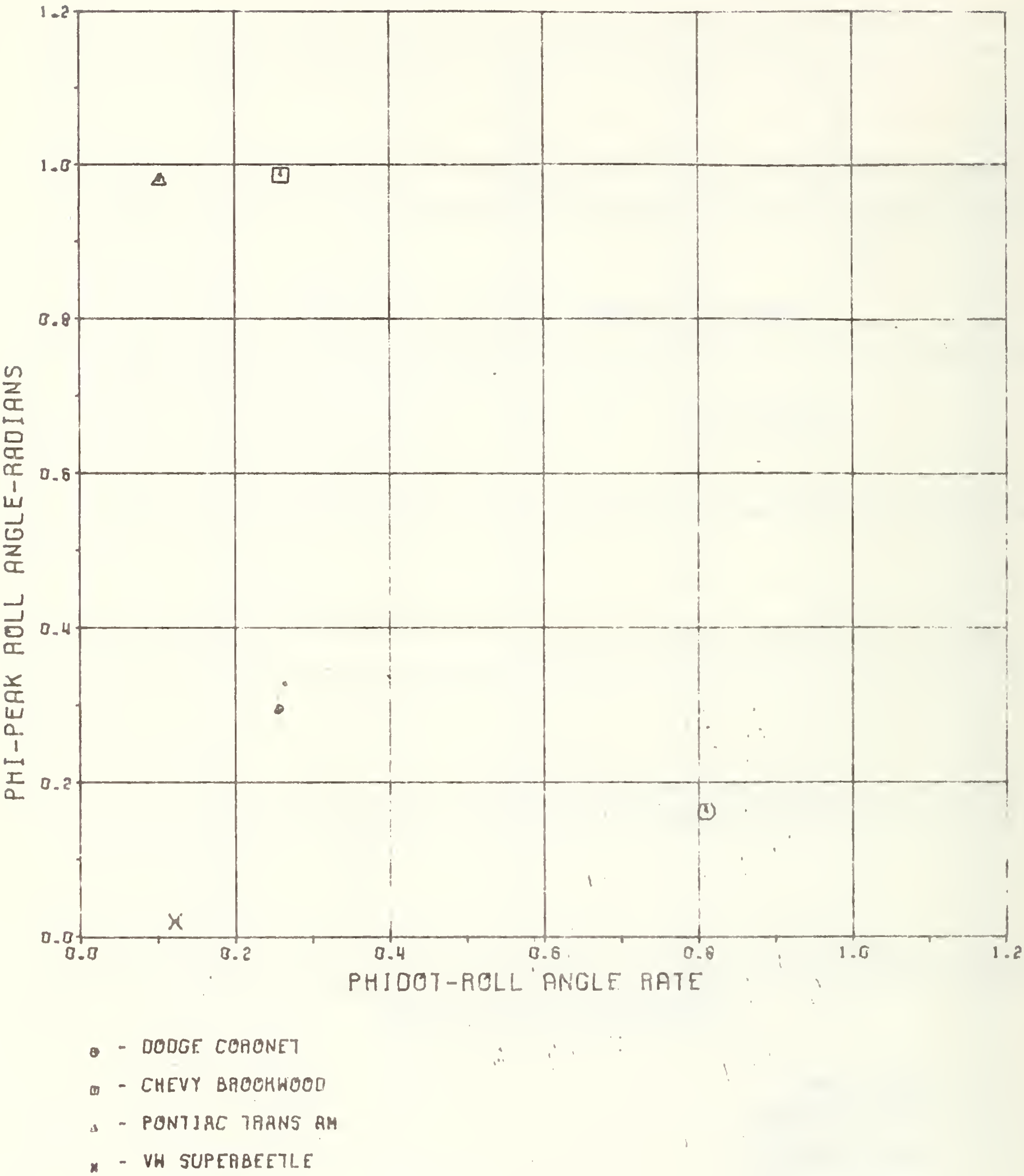
*** ROLL ANGLE VS. ROLL ANGLE RATE ***

(CALSPAN, O.E. TIRES, DRASTIC STEER & BRAKE-60 MPH)



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GPO 884-680

handling program.

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